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ANNALS
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LXXIII

THE HUMAN OSSICULAR LIGAMENTS

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Controversy has arisen from time to time as to whether or not the human ossicles possess true joints and ligaments comparable with those of other bones of the body. Anatomically, a joint is defined as the articulation of two or more bones, the opposed ends of which are covered with hyalin cartilage; are bound together, and are enclosed by a joint capsule consisting of ligamentous fibers arising from the periosteum of the opposing bones. The capsule is lined with an endothelial membrane, the synovial membrane, which secretes the fluid that keeps the joint surfaces moist. An interarticular cartilage is frequently present.

Approximately six variations of the above described mechanism are recognized as true joints. Classification of the ossicular joints is extremely difficult. They do not fit neatly into the specific groups that have been devised for the larger joints of the body. Nevertheless, they are true joints. From the point of view of the anatomist, they are phylogenetically, second only to the vertebral joints in age. Routinely these tiny joints exhibit no folds in the synovial membrane for increased production of fluid. One instance of this mechanism has been noted in an incudostapedial joint, however, by one of the authors, in the course of years of observations on hundreds of ossicles.

From the Otological Research Laboratory of the Manhattan Eye, Ear and Throat Hospital, New York.

A ligament has been defined as a sheet or band of fibrous tissue connecting two or more bones, cartilages, or other structures or serving as support for fasciae or muscles. Certainly the ligaments of the ossicles fall in these categories, even the superior ligaments, which are often scarcely more than delicate mucosal folds.

Because of the increased interest in the ossicles as coupling devices serving in the transmission of sound across the middle ear cavity, a restudy of the demonstrable anatomic nature of the ossicular joints and their associated ligaments, seems timely. This may throw some light on results obtained in the mobilization procedure.

OBSERVATIONS

The following observations are recorded as a result of the microscopic survey of ossicular joints and ligaments in two-hundred temporal bone specimens in the collection of temporal bone sections in the Otology Laboratory of the Manhattan Eye, Ear and Throat Hospital. Most of this material was collected and prepared under the direction of Drs. Marvin Jones, Hemsath and others who have worked in this laboratory in the past.

The short process of the incus bears on its inferior surface, near the posterior tip, a deep notch (previously described in the literature by one of us) which is filled with dense fibrous tissue. This in turn is attached to atypical cartilage which lines the roof of the notch. The notch is most advantageously demonstrated, histologically, in sections of an exterpolated incus. It is observed in sections in situ, only when the temporal bone has been cut vertically, in the plane of the long axis. This plane of cutting is uncommonly used and the block of tissue is rarely sectioned sufficiently far laterally, to include all of the ossicular ligaments. Occasionally the notch is expanded to extend across the tip of the short process and through the depths of the bone, to the upper surface, thus completely separating the extreme tip of the short process, as a minute accessory ossicle. Embryologically, in the human ear, this area may often be seen as a distinct and separate cartilaginous mass, posterior to the incus proper.

Routinely the short process of the incus is seen in the horizontal sections of the petrosa as illustrated in Figure 1. At this level only the lateral portion of the posterior ligament is in evidence. More inferiorly the sections reveal both a lateral and a medial component in the posterior incudal ligament. The lateral component first appears at the level of the crista of the horizontal canal (Fig. 1). It

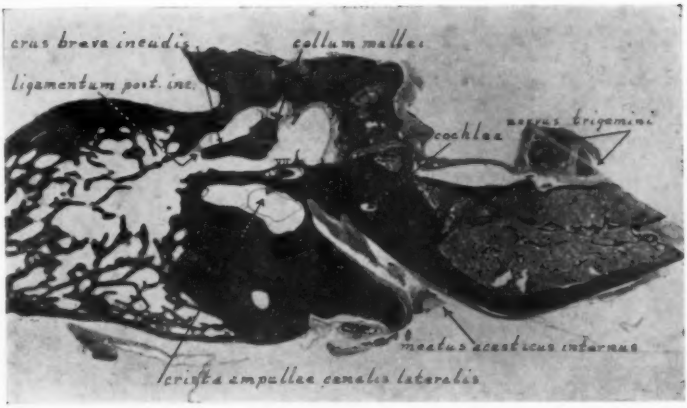

Fig. 1.—The short process or crus of the incus lies in the aditus ad antrum where it is firmly anchored by the posterior ligament of the incus. Here we see only the lateral component of this ligament.

is much more extensive than the medial component, covering a curving span of more than a millimeter over the posterolateral tip of the ossicle. Its most penetrating source of attachment to the ossicle is within the depths of the above-described notch. A very occasional specimen can be found, however, where the attachment does not enter the notch.

The attachment or insertion of the posterior ligament to the lateral wall of the fossa incudis extends over a span of approximately 2 mm at the level illustrated in Figure 2A. Here the ligamentous fibers blend with the periosteum in the depths of two crater-like depressions which lie contiguous with each other. The diameter of each of these two depressions in the lateral wall of the aditus ad antrum is 1 mm. The depth of the more anterior one is greater, being approximately 0.4 mm below the adjacent middle ear wall. The posterior depression is more shallow, measuring only 0.15 mm in depth, at this level. This posterior depression contains more dense fibers than the anterior depression. The ligamentous fibers are directed posterolaterally from their attachment to the ossicle to their attachment to the lateral wall of the fossa, as illustrated in Figure 2A and B. More inferiorly these dense fibers are concentrated in a groove which is 0.3 mm wide and 0.6 mm deep. The groove is illustrated in Figure 2C. Gradually this groove with its contained ligament sinks into the depths of the bone and becomes a discrete canal as illustrated

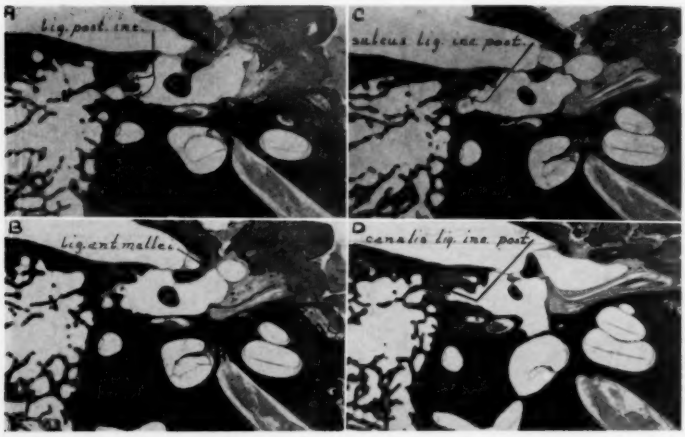

Fig. 2A.—Note the fan-like spread of the posterior ligament of the incus. The lateral component is attached at this level in the depths of two basin-like depressions which lie contiguous with each other.

B.—The medial component of the posterior ligament of the incus is attached to a cone of bone protruding from the medial wall of the aditus. Anteriorly the anterior process of malleus lies embedded in the anterior ligament of the malleus.

C.—The lateral component of the posterior ligament of the incus continues inferiorly in a groove or sulcus in the bone.

D.—The lateral component of the posterior ligament has now passed into a canal in the depths of the bone. It has continued inferiorly to the level of the foot-plate of the stapes. See enlargement, Figure 3.

in Figure 2D and enlarged in Figure 3. Thus in reality the posterior portion of this lateral attachment of the posterior incudal ligament is much deeper than the anterior portion. As indicated in the illustrations, in this specimen, it extends inferiorly, to the level of the foot-plate of the stapes.

The medial component of the posterior incudal ligament is less extensive and contains fibers of much less density. Its attachment over the proximal surface of the ossicles covers a span of approximately 0.8 mm in this specimen. On the medial wall of the fossa incudis a conical protrusion of bone occurs as may be seen in Figure 2A and more obviously in Figure 2B. This bony cone has a basal diameter of 0.5 mm and protrudes into the fossa 0.5 mm. Over the roughened

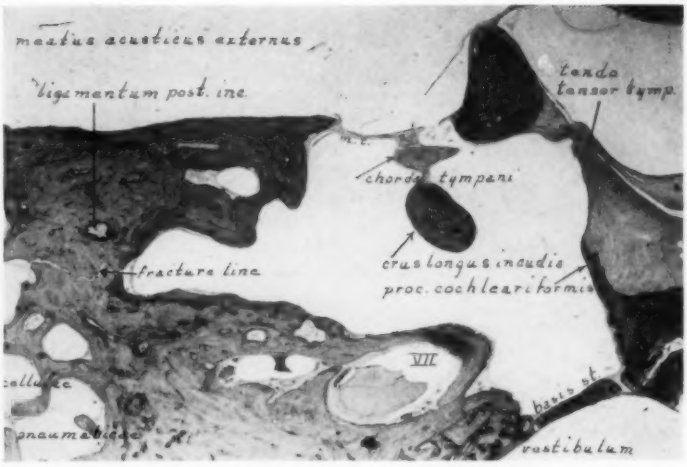

Fig. 3.—Enlargement of Figure 2D. The posterior ligament of the incus is clearly seen in cross-section, travelling in its own canal. Note the fracture line medial to it. Anteriorly, the lateral process of the malleus protrudes toward the external auditory canal and the tendon of the tensor tympani muscle fuses with the periosteum of the medial surface of the ossicle. Chorda tympani is seen travelling between the malleus and the descending process of the incus.

surface of this cone and around its base, the medial portion of the posterior ligament spreads for attachment.

We now pass to a consideration of the incudomalleolar joint and its capsule. Grossly the joint-surface of the incus presents a configuration, as seen on the dry ossicle, somewhat like that of a gaping and slightly twisted mouth, since it has an upper and a lower surface, meeting in the depths of the bone at midline of the body of the ossicle. The malleus presents a smaller articular surface on its head. Comparable irregularity is here present, except that where the surface of the incus is depressed, the corresponding surface of the malleus is heaved outward, as in positive and negative impressions. When in apposition, these two jaw-like surfaces interlock firmly as observed in Figure 4. How firmly they articulate with each other is well-known to the surgeon who attempts to disarticulate them on the operating table.

The articular surface of each ossicle is covered with hyalin cartilage and between them extends an interarticular cartilaginous disc.

Fig. 4A.—The intricate interlocking of the malleoincudal joint surfaces is apparent. In addition, in this illustration, the descending process of the incus is seen to curve upward in a hook-like structure, before presenting the lenticular process to the head of stapes for articulation.

B.—The incudostapedial articulation is in evidence in this section. For greater detail of this articulation see Figure 7 where the joint appears as in horizontal section and at the level of the attachment of the tendon of the stapedial muscle.

The articulating surface of each bone is slightly raised from the major portion of the structure, as if on a little platform, well illustrated in Figures 5 and 6. This allows the formation of a rough lip, surrounding each articular surface, for the firm attachment of the fibers of the joint capsule. A study of serial sections reveals that the interlocking of the two ossicles is controlled, not only by the shape of the apposed bones, but also by variations in the density, thickness and length of the fibers of the joint capsule, as well as by their manner of insertion in different regions. At some levels as in Figure 1 the lateral portion of the ligament is by far the thicker and more dense; at other levels the median fibers are thicker, longer and more numerous. The thickness of the capsule in this specimen varies from 0.06 mm to 0.2 mm. In the region illustrated in Figure 1, the thickness of the capsule on the medial side is 0.07 mm in midcourse, whereas on the lateral sides its thickness is 0.2 mm. The length of fibers on the medial side is 0.9 mm, whereas on the lateral side the length at

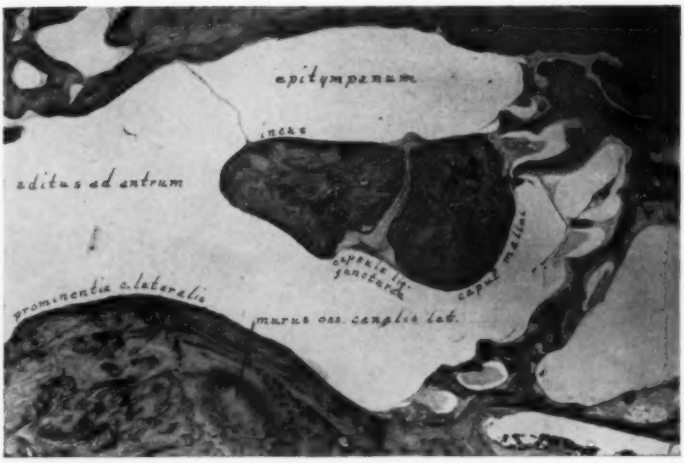

Fig. 5.—The incudomalleolar joint with its interarticular cartilaginous disc is apparent in the epitympanum. Note that the articular surface of each ossicle is erected a little higher than the main body of the bone. The lateral joint capsule protrudes laterally, having been stretched out of normal position by the subluxated disc. The fan-shaped spread of the medial portion of the capsule is obvious as it attaches to different levels of the bony surface.

this level is only 0.6 mm. At a more superior level, illustrated in Figures 5 and 6, the medial capsular fibers are thicker, longer and heavier than the lateral. The medial ligament measures 0.15 mm in thickness in midcourse and is 0.9 mm long; the lateral ligament is .036 mm in thickness and, stretched, would measure 0.8 mm. But this thin lateral ligament in this region has been subjected to extrusion by the interarticular cartilaginous disc and therefore bows outward considerably. The medial capsular fibers are seen to fan out extensively as they approach their ridge of attachment. The incudal fibers attach on two sharply differentiated levels of bone, with a span of 0.4 mm for attachment, while on the malleolar side the fibers spread over a more rounded uneven surface of approximately 0.5 mm. The thin lateral capsular fibers arising from the incudal surface are little more than an extension of periosteum, but on the malleolar surface these same fibers attach over a shallow depressed span of 0.1 mm. The fact that the capsular ligament gains extra purchasing power by arising from periosteum on two levels of bone is apparent in the illustrations.

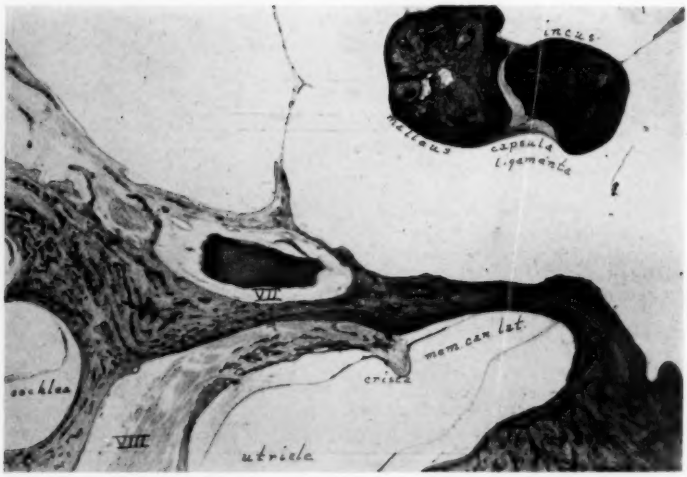

Fig. 6.—The incudomalleolar joint at this level exhibits the raised platform of the articular surface, particularly on the malleus. The positive-negative structure of the interlocking surfaces is seen to some degree, but not so obviously as in the vertical sections shown in Figure 4.

The suspension of the neck of the malleus, both anteriorly and posteriorly, in dense fibrous tissue, which is an extension of the periosteum of the malleus, is illustrated in Figure 2A, B and C. This ligamentous suspension is so firm that it provides an axis around which the malleus and incus can rotate. The mucosa which covers these anterior and posterior ligamentous bands forms the anterior and posterior malleolar folds. The anterior ligament is by far the stronger and thicker. It embraces the anterior malleolar process which is an ossified remnant of the embryonic Meckel's cartilage. This structure serves as the "core" around which the growing dermal bone of the mandible develops during and after the fourth fetal month. The anterior ligament is thinner on the medial side over which the chorda tympani travels in parallel course with the anterior bony process. On the lateral side it thickens to 0.1 mm and appears to be as thick as 0.6 mm because it fuses with very dense fibers running laterally and vertically in the region. These attach to the spina tympanica posterior of the tympanic bone. In the intact specimen the long fibers of the anterior ligament continue through the tympanic fissure, extending as far as the spine of the sphenoid bone.

Fig. 7.—The incudostapedial joint shows an interarticular disc in this specimen, but this is not always present. The posterior capsular fibers are seen to blend with the fibers of the stapedial tendon. The superior attachment capsular fibers, both anteriorly and posteriorly sinks deep into irregular roughened depressions above the lenticular process. Firm attachment to the shaft of the descending crus of the incus is thus assured.

The enveloping nature of the tendon of the tensor tympani muscle in relation to the neck of the malleus is apparent in Figure 3, where it is observed to be more or less continuous with the thickened periosteum covering the blunt-nosed lateral process. The attachment of the periosteum of the handle of the malleus to the drum membrane seems to occur only at the umbo (at least in this specimen) although it is attached by mucosa along its whole length. The concentric fibers of the drum membrane collect at the spatulate tip of the manubrium of the malleus and here blend with the periosteum of the bone, over an estimated 0.9 sq mm area.

The descending process of the incus is well illustrated in Figure 4A, where it is seen to descend, then curve slightly upward to reach the head of the stapes. The lenticular process at the end of this upward curvature is occasionally an accessory little bone.

We shall now consider the nature of the incudostapedial joint as illustrated in Figure 7. The capsule of the incudostapedial joint is composed of fibers which are proportionately much longer than those which enclose the malleo-incudal joint, but they are of comparable thickness and comparable variation in thickness. The incudostapedial joint exhibits a joint space, in the specimen illustrated in Figure 7, which is 0.042 mm in depth. Within the space and not filling it, is a tiny interarticular cartilage, 38 microns thick. This interarticular disc is not present in all specimens. The joint is enclosed in ligamentous capsule, the posterior fibers of which form a mass, 0.07 mm thick. These fibers are attached to the roughened surface of the head of the stapes for an extent of 0.2 mm and over the lenticular process and the shaft of the incus in a curved depression, measuring approximately 0.5 mm. It is very important to note that inferiorly the posterior capsular fibers blend with those of the tendon of the stapedial muscle, as is well demonstrated in Figure 7.

Anteriorly the capsular ligament is thicker, measuring 0.09 mm opposite the joint space. These fibers are attached to the head of the stapes on two distinct levels of bone as illustrated in Figure 7. The attachment to the lenticular process curves extensively, even more than it does on the posterior surface. It attaches over a span of 0.2 mm on the upper surface of the lenticular process and along depressions in the shaft of the descending crus or process of the incus for a distance of 0.6 mm. Inferiorly the joint capsule is very heavy, dense and extensive, although the section illustrated in Figure 4A is not sufficiently enlarged to demonstrate this detail. The full length of ligamentous capsular fibers in this region is 1 mm of which 0.5 mm lie above the lenticular surface. The fibers converge to attach to relatively sharp jagged spurs of bone. Attachment is also made to cartilaginous surfaces. The diameter of solid bone in the lower hook-shaped or curved region of the shaft is 0.45 mm in this specimen chosen as a normal, for detailed measurement.

Thus it may be seen that the anchorage between the incus and the stapes is likewise very firm. The blending of the posterior capsular fibers with the tendon of the stapedius muscle near its attachment to the stapes, means that every time the muscle contracts it not

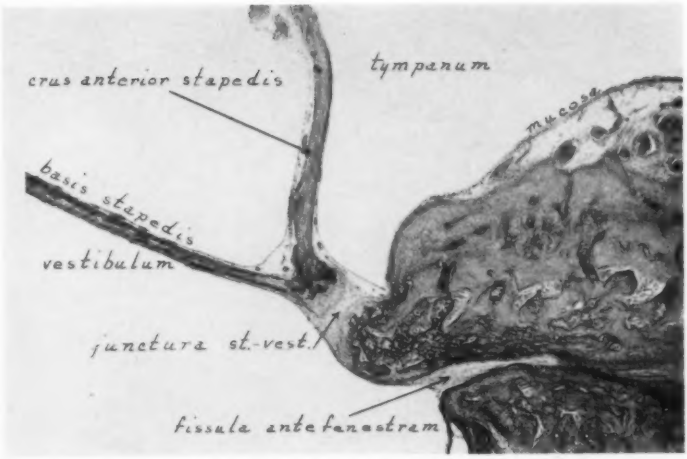

Fig. 8.—The annular ligament is here seen at the anterior region of the stapediovestibular joint, in close juxtaposition to the anterior stapedial crus and to the fissula antefenestram.

only pulls the stapedial head posteriorly but also the descending process of the incus. Furthermore, movement of the malleus, when that ossicle happens to be firmly locked with the incus, would be transferred to the head of the stapes, quite directly.

Finally we come to observations on the annular ligament of the stapediovestibular joint. The component fibers of the ligament do not merely form a capsule but a firm radiating anchorage throughout the distance between the opposed cartilage-covered surfaces of the bones involved. This arrangement seems to be unique among the joints of the body, in that ligamentous fibers traverse the joint throughout its course. The width of the annular ligament in the vestibulotympanal direction (as illustrated in Figure 8 in an infant) measures 0.35 mm. In the adult stapes, illustrated in the preceding studies (Figures 1-7), the measurement was 0.4 mm. The peripheral fibers of the annular ligament are more concentrated than those crossing the middle of the joint-space and, of course, longer. These peripheral fibers fuse with, and practically are, thickened periosteum and endosteum, respectively. The length of the intracapsular fibers at the root of the anterior crus of the stapes, in both infant and adult, is 0.1 mm. At the location of the root or base of the posterior

Fig. 9.—Detail of Figure 8, showing the endosteal fibers on the inner surface of the foot-plate of the stapes continuing into the fissula antefenestram.

crus of the stapes, the length of these fibers is 0.055 mm. Intermediate regions, measured in the adult specimen from which the sections illustrated in Figure 4 were taken (a specimen cut at right angles to the long axis of the petrosa), yielded 0.052 mm superiorly and inferiorly. These measurements gradually shifted to the longer measurements above cited, as the serial sections were read. Some fibers originating on the inner side of the foot-plate or endosteal surface actually crossed the joint and attached to the periosteum on the middle ear side of the otic capsule, traversing a distance of approximately 0.6 mm. How much stretching of these elastic fibers can occur without rupture, we do not know. The presence of fibers traversing the joint space does not lead us to classify the joint as a synchondrosis since evidence of movement of the stapes can be instigated with minute units of pressure.

Measurement of the peripheral capsular fibers on the vestibular side of the stapediovestibular joint is difficult to estimate since the fibers are continuous with the endosteum and the endosteum on the whole foot-plate stains positive with elastic tissue stain. Discrete fibers obviously extend into the fissula antefenestram, as noted by Brunner.

Our measurements of this distance vary from 0.5 mm to 0.9 mm. Posteriorly the fibers may extend far enough to cover the fossula post fenestram, usually curving a distance of 0.6 mm. Posteroinferiorly, as seen in sections cut at right angles to the long axis of the petrosa, the endosteal ligamentous fibers are continuous with those of the spiral ligament of the basal turn of the cochlea, just within the promontory, at the point of the superolateral attachment of the spiral ligament. This fact may have significance in regard to maintenance of acuity of hearing, when the stapedial foot-plate is extirpated. The spiral ligament does not contain elastic tissue fibers, according to our observations.

The anterior external or tympanic capsular fibers of the stapediovestibular joint measure 0.5 mm in adult horizontal sections and in the infant that much and more because they occasionally enter a fissula antefenestram, still patent on the middle ear side. Posterior peripheral fibers measured 0.6 mm. These surprisingly long fiber-measurements do not indicate greater play of movement posteriorly, since the intracapsular fibers are much shorter.

COMMENT

Helmholtz recognized the presence of the notch in the short process, although he did not describe it as such. He did state on page 133 of *Sensations of Tone* (English translation by Ellis, 1858): "The tip of the short process, on the other hand, by means of a short ligament and an imperfectly developed joint at its under surface, is connected with the back wall of the cavity of the drum (tympanum), at the spot where this passes backwards into the air cavities of the mastoid process behind the ear." Helmholtz was, of course, observing this grossly. Microscopic serial sections alone can reveal how far the fibers of the posterior ligament may continue inferiorly into the depths of the bone (Figs. 2 and 3).

Bast and Anson do not mention the notch in *The Temporal Bone and the Ear* but on page 351 they definitely illustrate ossification occurring around the notch but not in it. This is a true presentation of what occurs and is the condition maintained in the adult.

During evolutionary cephalogenesis vertebrates found it expedient to incorporate one after another of the series of anterior gill arches into the construction of jaws. In so doing, the component segments of the gill bars nearest the head became foreshortened and the joints incorporated within the complex of skull bones. The notch of the

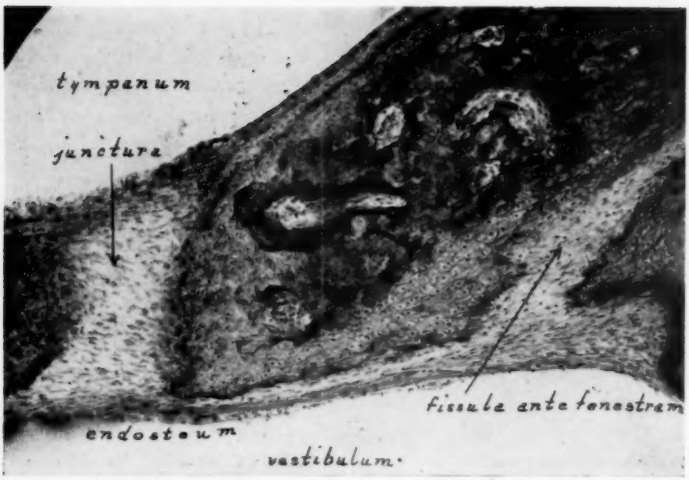

Fig. 10.—Detail showing vestibular endosteal ligamentous fibers extending from the inner surface of the foot-plate of the stapes, across the stapedio-vestibular joint and the fissula antefenestram, to insert in a depression in the vestibular wall, anterior to the fissula. The depression is probably really a part of the fissula.

short process which occasionally appears as "an imperfectly developed joint" and the long descending extension of the posterior ligament of the incus, described in this paper, are further evidence of a vestigial remnant of a jaw-complex antedating the malleoincudal jaw-complex, whose phylogenetic history is sufficiently portrayed in the ontogeny of all modern mammals, as to be self-explanatory. The continuation of the anterior process of the malleus, as Meckel's cartilage of the lower jaw, may be observed in the human in the fourth fetal month. The posterior ligament of the incus herein described is comparable to the anterior ligament of the malleus. But this earlier vestigeal joint-complex has been shoved more laterally and posteriorly. It represents a vestige of what Edgeworth describes on page 72 of his monumental work as "a first stage in which the lower jaw consisted of a Meckel's cartilage, articulating with the incus (quadrate) and with a short os mandibulare at the insertion of the Levator m. externus. This was followed by a second stage," . . . the fetal Meckel-malleoincudal articulation and a third stage, the present functioning jaw.

Stuhlman describes the articular face of the incus as that of a "figure eight." But a figure eight lies in one plane. This surface lies

in two planes or more. Helmholtz spoke of the joint as "saddle-shaped" but he did not mention that the saddle rides vertically. It cannot be described as a hinge-joint for no comparable action occurs. Helmholtz's reference to interlocking teeth of Breguet watchkeys seems more apt although many students have disputed this comparison. We do not see teeth in series, nor the actual "cogs" of Politzer but when these gaping jaws of the two ossicles are firmly fitted into each other and held by the dense elastic tissue fibers of the joint capsule, the movement is highly controlled. Harty has clearly described the elastic nature of these ligamentous fibers. Our elastic tissue studies of the joint ligaments will be presented in a later publication. The ligamentous fibers will not stain well with Mallory's collagen stain although they stain well with hematoxylin and eosin. The discrete bundles of elastic fibers can be demonstrated with MacCallum's elastic fiber stain. We have demonstrated that the bulk of the fibers in the stapedial muscle tendon are elastic. The continuity of the fibers of the posterior part of the stapediovestibular joint capsule with those of the tendon of the stapedius muscle, has not been previously demonstrated, so far as we know.

We concur with Brunner's observation that the fibers of the stapediovestibular joint continue into the fissula antefenestram for their attachment. We find that, posteroinferiorly, they are continuous with the attachment of the fibers of the spiral ligament of the basal coil of the cochlea. In the stapediovestibular joint we have observed that the elastic fibers not only form a capsule but thread their way across the lumen of the joint space, in both infants and adults. We are now of the opinion that where this is not the case, degenerative processes have already set in. We find that the elastic peripheral fibers of all joints are often seen to be continuous with the fibrous matrix of the solid bone, i.e., the interlamellar fibers. In these areas they are not mere continuations of the periosteum but have a much deeper origin and insertion, sometimes penetrating cartilage to reach this depth. Harty described these as "entering periosteal canals." A subsequent report will present elastic tissue stains of these joint ligaments.

210 E. 64TH ST.

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LXXIV

A METHOD OF REPAIRING A LARGE MARGINAL TYMPANIC PERFORATION

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Large marginal perforations of the tympanic membrane represent one of the most difficult reconstructive problems in otology.

A 39 year old woman developed an aseptic loss of approximately 25 per cent of the posterior marginal portion of the pars tensa between the second and fourth week following an otherwise successful stapes mobilization. There was no history to suggest that this was traumatic or the result of nose blowing, and it was therefore our impression that the perforation resulted from damage to the tympanic blood supply as the result of thrombosis or interruption of the annular vessels during mobilization.

Routine paper patching methods were tried but were unsuccessful. However, as long as the patch remained in situ the hearing improvement obtained during surgery persisted. An attempt was therefore made to reconstruct the defect.

TECHNIQUE

The ear was prepared in the same manner as a stapes mobilization and anesthesia obtained by injecting a few drops of a mixture of 2 per cent xylocaine 3 cc and 1:1000 adrenalin 1 cc in each of the four quadrants of the membranous external auditory meatus.

A large pedicle flap of the thin posterior membranous external auditory canal was then outlined as shown and elevated.

Following this, the bony margin of the perforation was thoroughly curetted and the annular sulcus obliterated (A). The tympanic margins of the perforation were then lightly cauterized with trichloracetic acid and the flap placed in position over the perforation as shown in (B), and held there by a round parchment paper disc against which was placed a small amount of fine gauze packing.

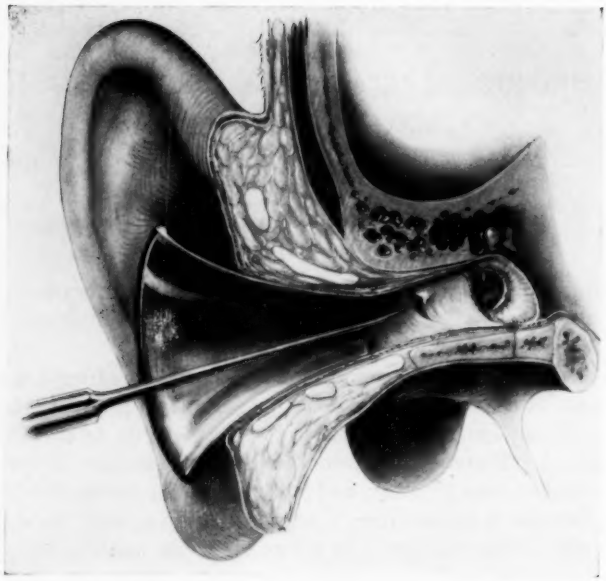

Fig. 1

The packing and disc were removed five days later. The flap was found to be thick and swollen but of good color and in position.

No increase in hearing was apparent at this time, but in subsequent observations at weekly intervals the flap was seen to become gradually thinner (c), with a concomitant improvement in hearing.

REPORT OF A CASE

The patient, E.S., 39 years of age, was first seen on Wednesday, February 15, 1956, with a history of tinnitus and hearing loss in both ears of 16 years' duration. Her father was hard of hearing and she had worn a hearing aid in her right ear for six years.

Puretone and speech audiometry revealed a well advanced clinical otosclerosis, and a stapes mobilization was carried out on the left ear on March 20, 1956. Audiometric studies during surgery showed an increase in equivalent speech reception thresholds from 50 decibels to 30 decibels with mobilization. On the day following surgery the usual clot was aspirated from her left ear, and inspection of the eardrum revealed it to be intact and in position. Although the usual ecchymosis was present, her marked improvement in hearing was clinically apparent at this time and also one

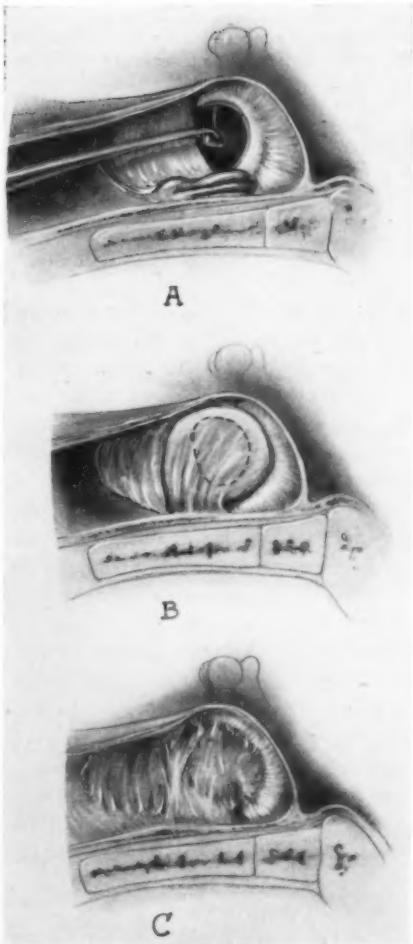

Fig. 2

week later on March 26, when the eardrum was again examined and again found to be in position and within normal limits. The patient was then seen one month later on April 27, complaining of decreased hearing and a large marginal, dry perforation was found to occupy the entire posterior one-third of the eardrum, including the margin and annulus area. There was no history of discharge from the ear and she denied vigorous nose blowing.

An attempt was made to patch this in the routine manner with a paper patch and was unsuccessful, although the hearing improved while the patch was in place.

One month and a half later, on July 5, a flap of tissue was transposed from the bony ear canal wall to the area of the perforation, which had been previously freshened by means of curettage and trichloracetic acid cauterization. The flap was held in place by light packing, and the postoperative convalescence was uneventful. The patient's hearing has slowly improved as the healing graft has thinned and tightened.

SUMMARY

A method of repairing a large marginal tympanic perforation by means of a sliding canal wall pedicle flap is described and a case reported.

490 Post Street

LXXV

OSTEOGENIC SARCOMA OF THE SKULL FOLLOWING IRRADIATION

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The role of radiant energy in the genesis of malignancies has become increasingly evident as a result of the physical, chemical and biological research on experimental animals and the accumulation of clinical data during the past half century.

The occurrence of bone sarcoma is considered one of the hazards of prolonged and excessive local irradiation for diseases, benign or malignant, not predisposing to such a tumor. According to Jones,[1] bone is the connective tissue most likely to develop irradiation sarcoma because of its high equivalent atomic number and particularly since it is a common site of primary sarcoma.

A review of the literature revealed 43 well documented cases of irradiation sarcoma of bone reported since the first description by Beck in 1922.[1-23] These neoplasms appear to develop following local therapeutic or prophylactic irradiation from external sources. However, osteogenic sarcomas following internal administration of radioactive substances, as in radium poisoning, have been recognized as a potential industrial hazard;[24-26] internally administered radium is a "bone seeker" and causes damage mainly to bone and bone marrow.

Cahan et al.[16] in a very comprehensive study have established four criteria for the selection of the postirradiation sarcoma of bone: 1) microscopic or roentgenographic evidence of the non-malignant nature of the initial condition; 2) the origin of sarcoma in an area encompassed in the radiation field; 3) a relatively long, symptom-free latent period and 4) histological diagnosis of sarcoma.

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The comparative location of irradiation sarcoma of bone is very similar to that of primary bone sarcoma: the majority of the reported cases involve the long bones. The low incidence of irradiation sarcoma in the frequently and intensely irradiated skull bones for both benign and malignant conditions has not yet received a satisfactory explanation. Perhaps, the dosage delivered for benign conditions such as skin disorders, hyperplastic tonsils and adenoids, sinusitis and cervical adenitis is too small to cause bone sarcoma and only a few of the heavily irradiated patients for cancer of the head and neck structures survive sufficiently long.

Eight cases of irradiation sarcoma in skull bones have been reported in the literature (Table I). The seriousness of its implications related to the involvement of vital structures and difficulty of treatment, both surgical and by irradiation, deserves further consideration.

Two cases of osteogenic sarcoma arising in areas previously irradiated, involving the temporal and frontal bones, motivated a study of the clinical, radiological, pathological and therapeutic aspects of irradiation sarcoma of the skull in order to achieve a better understanding of this entity.

REPORT OF CASES

CASE 1. L.G., white male, was 20 years old when sarcoma developed. He was first seen by one of us (E.M.S.) on January 22, 1952.

At the age of 14 this patient fell on a piece of wood which embedded itself under the skin of the left postauricular area. It was removed and new tissue formed in the site of the incision. This tissue which was diagnosed as a keloid was removed on three occasions, each time with recurrence. The patient was referred to a local physician for irradiation.

From June 30, 1947 to August 10, 1948 the patient received a total of sixteen treatments to the left postauricular area. These treatments were given as superficial therapy, at a distance of 15.1 centimeters to a five centimeter port; 124 KV therapy with ¼ mm Cu and 1 mm Al filter was used. At first his treatment consisted of 200 r/air given on June 30, on July 3, on July 7, on July 14, on July 21 and on August 4, 1947. He then received 500 r/air on August 18, on September 2, on September 16, on October 30 and on November 28, 1947. A dosage of 600 r/air was delivered on December 29, 1947. Additional treatments of 500 r/air each were delivered on January 28, on March 15 and on May 10, 1948. During his last treatment on August 10, 1948, he received 250 r/air. The total dosage was therefore 6,050 r/air delivered with the above factors.

The patient did well until October 1951 when he developed a left-sided facial paralysis of gradual onset and apparently independent of active infection or pain. This was diagnosed as Bell's palsy and the patient was treated with several injections of an arsenical preparation without improvement. On December 6, 1951 an otological examination revealed a discharge in the left ear and a growth in the upper

TABLE I. COLLECTED CLINICAL CASES OF POSTIRRADIATION SARCOMA OF SKULL BONES

CASE	AUTHOR	YEAR	LOCATION	LESION TREATED WITH IRRADIATION	AGE AT ONSET OF SARCOMA	SEX	MODE OF IRRAD. AND DOSAGE	LATENCY FROM LAST IRRADIAT.	HISTOL. TYPE OF SARCOMA	TREATMENT AND END RESULT
1	Cahan et al.	1948	mandible	ossifying fibroma, microscopic	23 yrs	M	x-ray, 4500 r tum. dose in 2 yrs	6 - 7 yrs	osteogenic & /or fibrosar.	resection recur. 4 m invas. of dura lyr
2	Cahan et al.	1948	maxilla	cloudiness maxillary sinus	26 yrs	F	x-ray, 3600 r tum. dose in 20 mos	13 yrs	osteogenic sarcoma	resection living and well 4 yr after
3	Cahan et al.	1948	ethmoid	retinoblastoma	9 yrs	F	x-ray 25,000 r tum. dose in 2 yrs	6 - 7 yrs	osteogenic sarcoma	resection recur. 3 m died 4 mo after
4	Kaae & Glahn	1949	mandible	gingival epithelioma	62 yrs	M	radium 1840 mg/hr in 2 sessions	13 yrs	fibrosarcoma	resection no follow-up
5	Wolfe & Platt	1949	nasal bone	lupus erythematosus	51 yrs	F	x-ray in 17 y 2000 r/air & radium in 4 y 1031 r	4 yrs	osteogenic sarcoma	no treatment destructive progr.
6	Wolfe & Platt	1949	nasal bone	acne	34 yrs	M	x-ray, dose unknown	18 yrs	osteogenic sarcoma	resection well 1 yr after
7	Tebbet & Vickery	1952	ethmoid	retinoblastoma	9 yrs	F	x-ray 19,800 r/air in 11 mos	6 - 7 yrs	osteogenic sarcoma	resection recur. 1 m recur. 4 m
8	Jones	1953	mandible	actinomycosis	28 yrs	M	x-ray, 6,700 r tum. dose in 2 yrs	7 yrs	osteogenic sarcoma	resection recur. 2 m died 10 m after

posterior portion of the external auditory meatus suggesting granulation tissue. An x-ray examination of the mastoids at this time (transcript of therapy and x-ray report from local physician) revealed an entirely normal mastoid on the right side and changes consistent with chronic mastoiditis on the left. Biopsy was suggested to rule out a neoplastic process, but was refused by the patient.

When he was seen in January 1952 he had a complete peripheral facial paralysis on the left associated with nocturnal pain within his left ear and a moderate loss of hearing.

Physical examination revealed a well developed 20 year old white male with an obvious left facial paralysis of the peripheral type. The otolaryngological examination showed a normal right ear. There was evidence of radiodermatitis in the left postauricular region with discoloration and teleangectasis of the skin (Fig. 1). A moderate amount of purulent exudate was noted in the left external auditory meatus, which was almost completely occluded by the presence of a granular mass. Hearing evaluation revealed a moderate to severe hearing loss of the conductive type on the left side. Vestibular examination (Barany chair) was within normal limits. Examination of the nose, pharynx and larynx was normal as well as the remaining physical examination.

Roentgenographic interpretation at this time revealed a normal right temporal bone whereas the left showed fairly good cell development, but the lower half of the mastoid in the lateral view indicated a haziness which appeared to extend forward to the facial canal zone and partially deform the external auditory canal (Fig. 2). The internal auditory canal appeared normal bilaterally. Impression was that of a mastoiditis involving the lower portion of the left mastoid with encroachment upon the facial canal and external auditory meatus. A laminographic study of the left mastoid region confirmed a rarefaction involving the left mastoid process, the antral region and the middle ear area.

A biopsy taken from the left external auditory meatus was reported as granulation tissue.

The patient was hospitalized for exploration of the mastoid area in view of the clinical picture and the roentgenographic interpretation in contrast to the histopathological evaluation. A postauricular approach was selected and examination revealed the entire mastoid to be filled with a friable vascular neoplastic-like tissue with exposure of the dura in the region of the middle cranial fossa. A radical mastoidectomy was performed and the wound left open. Follow-up histological studies revealed anaplastic cells with round, spindle shaped and ovoid nuclei and vacuolated cytoplasm which form islands and cords in a fibrous stroma. Impression was that of a malignancy, probably fibrosarcoma.

The patient's family was told the seriousness of the condition, but further surgery was not permitted. Approximately two months later there was clinical evidence of residual with invasion of the parotid gland and palpable cervical lymph nodes. The patient at this time consented to a more adequate surgical procedure. A portion of the temporal and occipital bone was removed with the ear in continuity with a resection of the left parotid gland and left adequate neck dissection. A Tiersch graft from the left thigh was placed over the operative defect. Healing was satisfactory and the patient returned to his home after an uneventful hospital course.

The pathology report revealed in the cut surface a circumscribed mass, 5 x 3 cm, surrounded by nodules which ranged from 0.3 to 0.5 centimeter. This mass appeared gray white and studded with soft, grey yellow and dusky red areas. Microscopically, anaplastic cells of various sizes and shapes, single and occasionally multinucleated infiltrated in the form of islands and cords the fibrous interstitial tissue. Irregular bony spicules surrounded by osteoid tissue are scattered in the stroma (Fig. 3). His-

Fig. 1.—Case 1: Radiodermatitis of the left postauricular region.

tological examination of the lymph nodes showed only hyperplasia of lymphoid tissue. Impression was that of an osteoblast, osteogenic sarcoma.

The patient did fairly well until November 1952 when he was admitted to the hospital with the diagnosis of brain concussion following an automobile accident. He expired on November 25, 1952. No autopsy permit was obtained.

Case 2. K.M., white female; 11 years old when sarcoma developed. First seen at the Research and Educational Hospitals of the University of Illinois on June 22, 1950.

At the age of two months, this patient was found to have an "infection" in the left eye which was first noticed at the age of one week. The right eye appeared normal at this time. Examination of the left eye revealed a new growth and the eye was enucleated on November 29, 1938. The pathological diagnosis was retinoblastoma. The child was examined at frequent intervals without evidence of recurrence in the left orbit.

In September 1939, however, a large whitish mass was seen on funduscopic examination of the right eye. A diagnosis of retinoblastoma was made; the child was referred for radium treatments.

Several external radium treatments were given from October 1939 to March 1940. The growth in the right eye apparently did not respond well to external radium-applications; the child was readmitted to the hospital for interstitial radium therapy five months later. Three 3-mc radon seeds were inserted under the conjunctiva for five days. The total radiation given over a period of nine months was

approximately 9,600 mgm/hrs. The skin showed a considerable degree of reaction following the last radon treatment, but this reaction subsided gradually.

In March 1941, teleangectasis of the right sclera was noted. In May 1943, a cataract with keratitis developed. The child was then placed in the Illinois School for the Blind and seen infrequently for follow-up examinations. In 1946, diffuse adhesions between the eyelids and bulbus were noticed. The eyelids and conjunctiva were injected; the cornea was milky, the pupil obscured. The skin around the eye showed teleangectatic spots. There was some rhinorrhea which apparently had been persistent since the completion of the radium therapy.

In April 1950, a swelling was first noticed on the child's forehead. This swelling gradually increased; in June 1950 a mass protruded from the right nostril. The child was then referred to the Illinois Research Hospitals for further therapy.

Physical examination revealed a chronically ill 11 year old white female, somewhat apathetic, but co-operative. Examination of the head revealed a rounded, smooth, non-ulcerated, hard swelling over the right side of the forehead and right side of the nose approximately 11 centimeter in length, 5.5 centimeter in width and 2.5 centimeter in depth with a dusky, reddish blue discoloration of the skin overlying it (Fig. 4).

Ophthalmological examination revealed absence of the left eye, previously enucleated and substituted by a prosthesis; the left socket was fairly clean. Radiation fibrosis of the cornea of the right eye was noticed. Vision was limited to light perception and hand movements. Nystagmus was constant and appeared of a horizontal and rotatory type, rapid in character and short amplitude. A foul smelling, yellowish, mucopurulent exudate was expressible from the tumor and appeared over the right eye.

Otolaryngological examination revealed the above described swelling. A large, firm, greyish mass completely occluded the right naris and nasal cavity, displaced the nasal septum to the left and obscured any visualization of structures on either side. Foul, purulent secretion was coming from both nasal cavities. The mass extended posteriorly into the nasopharynx occluding both choanae. A bilateral subacute catarrhal otitis media was noticed. Oropharynx, hypopharynx and larynx appeared normal. Transillumination revealed opacity of the sinuses on the right side.

The x-ray examination of the skull and paranasal sinuses revealed a large soft tissue mass in the region of the right side of the face, the forehead and in the right nasal cavity. Marked sclerosis was present in the region of the frontal bone close to the right frontal sinus with "sun ray" like spicules extending from the outer table toward the soft tissue mass (Fig. 5). There also appeared to be some destructive changes in the inner table of the frontal bone. The right maxillary sinus, the right ethmoid and the right sphenoid sinus appeared opaque. The medial wall of the right maxillary sinus appeared to be destroyed; partial destruction of the nasal septum was poorly defined. The left frontal sinus was ill-defined, the other sinuses on the left being fairly clear. A prosthesis was noted in the left orbit. Chest x-ray was within normal limits.

From the clinical and radiological evaluation the lesion was interpreted as a probable osteogenic sarcoma, postirradiation, arising from the anterior wall of the frontal bone in the region of the right frontal sinus.

A punch biopsy of the mass in the right nostril was taken, but revealed chronic inflammatory tissue. A biopsy was therefore performed in surgery using a tonsil snare; the vigorous bleeding that followed was controlled with a pressure pack. The specimen was 1.5 centimeter in diameter by 1 centimeter in thickness. Microscopically, the outer edge of the section consisted of edematous, fibrous connective tissue

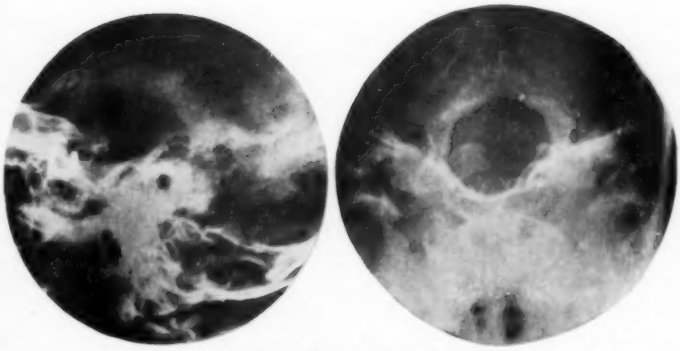

Fig. 2.—Case 1: A. The Schüller view reveals a haziness involving the lower half of the left mastoid process, associated with cellular destruction. B. The Towne's view shows an ill-defined left mastoid tip with opacity involving the external auditory canal and cavum tympani.

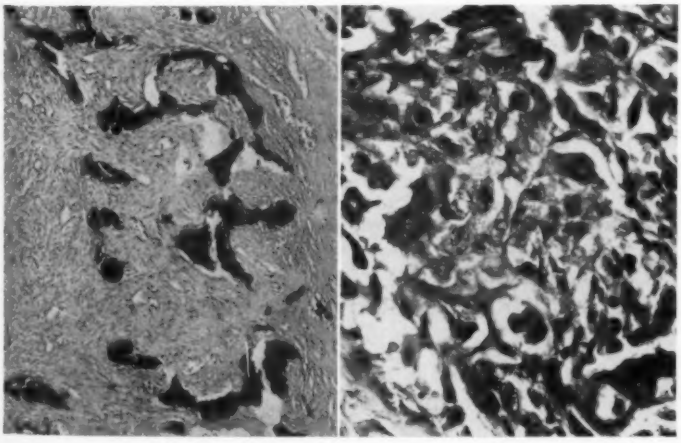

Fig. 3.—Case 1: A. Low power magnification reveals irregular bony spicules scattered in the fibrous stroma. B. Higher magnification shows anaplastic cells of various sizes and shapes, single and occasionally multinucleated, infiltrating the fibrous interstitial tissue.

stroma infiltrated by numerous eosinophilic polymorphonuclear leukocytes and lymphocytes. In the center portion of the specimen lobules of pleomorphic cartilage tissue were seen. The cartilage cells were atypical and varied considerably in size and form. The nuclei of the cells were hyperchromatic and the cytoplasm was vacuolated. Along the periphery there was myxomatous-like stroma. Impression was that of a chondrosarcoma involving the nose.

Because of the extent and type of tumor, no form of definitive therapy was deemed possible. However, Betatron therapy was considered as a palliative measure.

Following discharge from the hospital the patient began having headaches. She was rehospitalized one month later following a generalized left-sided convulsion. Re-examination at this time failed to reveal any localizing sign. Her final admission to the hospital occurred one month later because of severe dyspnea and hemoptysis. Examination at this time showed the soft palate displaced downward by a pharyngeal mass with encroachment on the airway. She failed to respond to therapy and died in asphyxia.

At autopsy the patient's face was grotesquely distorted by a massive nasal tumor which protruded from the right nare and which extended subcutaneously over the glabella. This tumor, which involved the right ethmoid sinus, the right nasal bone and the nasal septum, distended the right nasal chamber, occupied the nasopharynx and oropharynx and extended down into the hypopharynx. It eroded through the bony walls of the right ethmoid sinus into the right orbit, the right maxillary sinus and the sphenoid sinus. A large intracranial extension of this tumor had eroded through the cribriform plate of the right ethmoid and the orbital plate of the right frontal bone and was displacing, but actually not invading the right frontal lobe of the brain.

The various extensions of this neoplasm were lobulated, frequently circumscribed and predominantly cartilaginous or gelatinous. The portion over the glabella, however, was firm and opaque.

No intravascular invasion, lymphatic spread or metastasis of this tumor was seen.

Histologically, the largest part of this tumor was comprised of abnormal cartilage; however, in the firm area over the glabella neoplastic cells produced osteoid and bone. In the chondrosarcomatous portion of this tumor (Fig. 6a) the cells were large and plump with coarse clumping of the nuclear chromatin. Binucleated cells were frequent and in some areas the cells were very numerous. Many areas of myxomatous degeneration were present. In that portion of the tumor which was histologically an osteogenic sarcoma (Fig. 6b) abnormal chromatin clumping and variations in size and shape were noted in the nuclei of the tumor cells which were producing osteoid. In some areas calcium deposits converted the osteoid into bone. Numerous vascular spaces lined by neoplastic cells were present in the bone producing portion of this sarcoma.

Histologic sections of the right retina and optic nerve revealed no recurrence of the retinoblastoma.

RELATION OF IRRADIATION TO BONE SARCOMA

Osteogenic sarcoma has often been related in the past to benign conditions such as myositis ossificans, fibrous dysplasia, osteitis deformans (Paget's disease) and giant cell tumor.[27] It is only after the advent of x-ray therapy and the study of the hazards involved in its wide use that irradiation has been considered an important factor

Fig. 4.—Case 2: Swelling over the right side of the forehead and nose which is hard and rounded and associated with radiodermatitis. A firm, greyish mass protrudes from the right naris.

in the production of osteogenic sarcoma of bone. Several factors listed below deserve exemplification.

The effect of age at time of irradiation. Bone sarcoma following irradiation developed in patients as young as nine and as old as 62. No definite relationship could be noted between the age of the patients and latency of development of bone sarcoma. However, the relative younger age of the group of postirradiation osteogenic sarcoma in comparison with the ages of primary osteogenic sarcomas[1] and the fact that the degree of alteration of bone growth following irradiation is inversely related to age, make the age factor an important one. The marked radiosensitivity of proliferating cells and growing structures in young individuals has been fully recognized. Experimentally, growth resumption with atypical bone formation after irradiation also showed the importance of the age factor.[28]

The dosage of radiation. According to Cahan et al.,[16] a minimum tissue dosage of 3,000 r is required for the development of osteogenic sarcoma. Smaller dosages have been reported for irradiation of benign lesions of bone such as fibrous dysplasia and bone cysts with subsequent development of sarcoma. However, it has been observed that such benign bone conditions may show evidence of sarcomatous changes without the presence of irradiation. The dosage reported for

osteogenic sarcoma of skull ones varies from 3,600 r to 25,000 r. The importance of relatively high dosages in the pathogenesis of osteogenic sarcoma of bone are consistent with the findings of Neuhauser et al.[29] that only dosages in excess of 2,000 tissue r will produce disturbances in bone irrespective of the age of the patient.

The mode of irradiation. The duration of irradiation has been considered by Jones of no significance in the production of sarcoma. As a matter of fact a time as short as two months for the whole course of irradiation has been sufficient for the development of osteogenic sarcoma. It should be noted, however, that in all the cases in which radiation time has been short, the initial lesion was a benign condition of bone that could spontaneously develop into a bone sarcoma. On the other hand, intense and prolonged irradiation was given to the cases in which the osteogenic sarcoma develop in normal bone.

Small doses repeated over a prolonged period of time are more dangerous than a single large dosage. The same conclusions were reached by Knierer[30] for skin sarcoma following irradiation, by Wilson and Brunschwig[31] for postirradiation sarcoma of soft tissue and by Buschke and Cantril[32] for roentgentherapy of benign giant-cell tumors of bone. The histopathological studies of irradiation are consistent with this assumption. Heller[28] demonstrated the bone damage occurring after external and internal irradiation. Using therapeutic doses of radiation growth is resumed, though atypical. She described a very early osteogenic sarcoma in a strontium 89 treated rat in a region adjacent to an area of continued radioactivity.

The latent interval. The minimal period for human neoplastic response has been considered by Cahan et al.[16] of three years. The figures reported vary from 3 to 22 years with a mean interval calculated by Jones[1] at 8.6 years. Among the cases of osteogenic sarcoma of the skull the shortest period was noticed in the case involving the temporal bone of 3.5 years. By calculating the latent interval from the end of irradiation to the clinical onset, we fail to consider the period of irradiation that may be significant (in our case 13 months). The longest interval was 18 years. The average value was 9 years.

The development of postirradiation osteogenic sarcoma has been considered similar to the development of leukemia in bone marrow and of epithelioma in the skin that has undergone atrophy following irradiation.

According to Ross,[33] the type of growth produced by prolonged gamma radiation depended upon the tissue in which the radium was

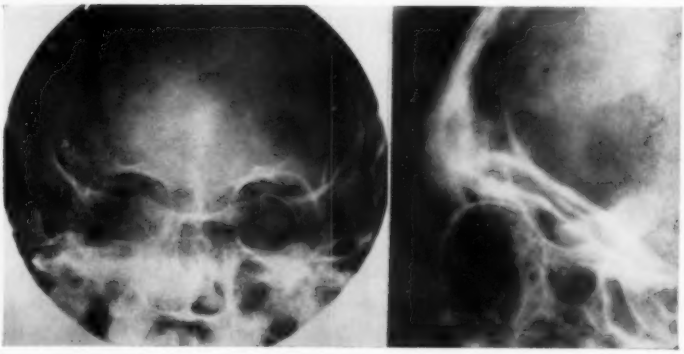

Fig. 5.—Case 2: A. The Caldwell view reveals a large soft tissue mass in the region of the frontal sinuses, right nasal fossa, right ethmoid and right orbital cavity. B. The lateral view shows marked sclerosis of the frontal bone with "sun ray" appearance.

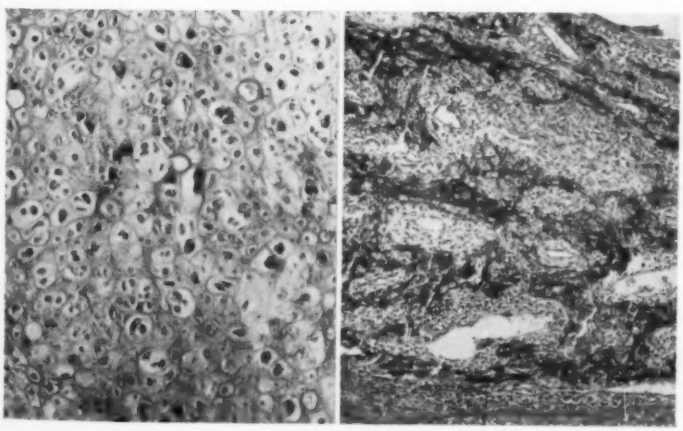

Fig. 6.—Case 2: A. The chondrosarcomatous portion of the tumor is characterized by large, plump cells with coarse clumping of nuclear chromatin. B. The areas of osteogenic sarcoma show irregular osteoid spicules surrounded by anaplastic cells with considerable pleomorphism of the nuc'ei.

embedded. The greater incidence of osteogenic sarcoma is probably related to the greater amount of energy absorbed by the bone in comparison with the soft tissue.

CLINICAL ASPECTS

Analyzing the ten collected cases, the relatively young age of the patients is apparent. The average age was 27 years with eight of the ten cases between 9 and 34 years. The three youngest cases were irradiated for retinoblastoma.

In the great majority of cases the postirradiation sarcoma developed within normal bones. The bone most frequently involved was the mandible, this fact being consistent with the comparative location of primary osteogenic sarcoma in the skull.

The diagnosis of a postirradiation osteogenic sarcoma of the skull on clinical grounds is extremely difficult and can be considered as a tentative impression to be corroborated with other evidence.

Cahan et al.[16] have maintained that "the most prominent symptom of malignant change was the rather sudden onset of steady and progressively increasing severe pain in the area." Only in half of the reported cases involving the skull, pain appeared to be present, localized to the involved area and varied from sharp and intermittent to dull and persistent. The pain may be due to tension on the intact periosteum or may develop secondarily with involvement of surrounding pain-sensitive structures.

Swelling was reported in nine of the collected cases and was perceptible on palpation and inspection. The swelling or "tumor" was localized to the involved region and usually of a firm, bony-cartilaginous consistency.

The possibility of extension of the tumor in the pneumatic cavities of the head and neck should be considered. The swelling of the mandible and maxilla was quite apparent at oral examination. In three cases a mass was visualized during the otolaryngological examination. Two of them involved the ethmoid and frontal bones with an evident mass in the nasal cavity. In one of our cases, a mass of "granulation tissue" was present in the external auditory canal. The importance of a thorough oral and otolaryngological examination cannot be overemphasized. The presence of a mass or a localized swelling in a natural cavity of the head and neck allows for accessible

biopsy of the neoplastic tissue. A diagnosis of such a rare condition as osteogenic sarcoma with a pleomorphism of unspecific clinical symptoms can be made only on histological studies.

A more characteristic clue to clinical diagnosis can be offered by skin changes. In three cases an ulceration of the skin or fistulous tract was noticed due to the initial condition or manipulation of the sarcoma. Secondary infection from the mouth or nose may cause ulceration of mucosa or skin. Spontaneous invasion of the skin by the neoplastic process and ulceration was not reported. In five cases the usual irreversible skin changes following irradiation were described. The severity of the radiodermatitis was evidenced in these cases by the presence of atrophy, pigmentation or discoloration, teleangectasis and hyperkeratosis of the overlying skin. However, the presence of irradiation skin changes should not be overestimated. The introduction of supervoltage therapy allows heavy irradiation of the deep structures with relatively mild skin changes. This consideration will probably be of greater significance in the future.

Functional disturbances of the eye, ear and face are worth mentioning. Significant may be the appearance of a nystagmus in the osteogenic sarcoma of the frontal bone following irradiation for retinoblastoma to exclude fixation of the eye. The osteogenic sarcoma of the mastoid presented in this paper had a peripheral facial paralysis as the most prominent symptom. Facial paralysis is a common finding in malignancies of the middle ear and mastoid[34] in relation to the vulnerability of the intratympanic segment of the facial nerve.

Laboratory work up may sometimes be of help, but it is rarely of diagnostic value. In particular, alkaline phosphatase is purely an index of bone production and therefore nonspecific.

The clinical course of postirradiation osteogenic sarcomas of the skull may be clearly demonstrated in our cases. If untreated, the tumor continues in its rapid growth filling the pneumatic spaces of the head and neck by invasion and erosion of the facial and cranial bones and usually ending with intracranial extension. If inadequate surgical resection has been performed or if response to irradiation has been poor, clinical evidence of residual occurs within a few months and invasion of the base of the skull and dura is the rule.

It is known that blood stream metastases, particularly to the lungs, are a common and early occurrence of osteogenic sarcomas of

the long bones, both primary and postirradiation. An analysis of the reported ten cases of bone sarcomas of the skull following irradiation failed to reveal any evidence of long distance metastases. The autopsy of our extensive osteogenic sarcoma of the frontal bone did not show any intravascular metastases, lymphatic spread or distant metastases. The pathologic specimen removed in the neck dissection of our case involving the temporal bone revealed only hyperplasia of cervical lymph nodes without neoplastic invasion. Chest x-ray and bone radiological survey were normal. Tebbet and Vickery[23] and Jones[1] report specifically no evidence of metastases in their extensive cases. No mention of distant metastases is made in the other reported cases of osteogenic sarcoma of the skull following irradiation. These considerations appear of extreme importance in the therapeutic management of these lesions.

RADIOLOGICAL ASPECTS

The radiological diagnosis of osteogenic sarcoma following irradiation is complex and most frequently impossible. This is due to: 1) the difficulty of visualizing adequately certain areas of the skull; 2) the absence of involvement of the bony structures (negative radiographic period) by neoplasm or other abnormalities; 3) the lack of specific characteristics; 4) the presence of remnants of the previously irradiated lesion.

Since the diagnosis of bone tumors is based on a tripod of findings: clinical, radiological and pathological, roentgenographic investigation may be of considerable help in establishing the presence of malignant changes without disturbing the pathologic anatomy of the neoplasm and in following the progress of the tumor. Therefore, serial films should be taken in various projections and of different penetration. Laminographic studies may be of great diagnostic value as in the case involving the temporal bone.

In the diagnosis and prognosis of a bone tumor a thorough clinical and radiological evaluation should always precede histopathological study, except when an exteriorization of the neoplasm is present. The roentgenographic picture can actually be a guide to biopsy-taking in order to avoid misinterpretation and complicating trauma.[35]

A rather constant roentgen appearance has been described in primary osteogenic sarcoma of the long bones[36] and in osteogenic sarcoma developing in Paget's disease.[37] In an attempt to diagnose osteogenic sarcomas of the jaws radiologically, Sherman and Melamed[38]

have considered three typical groups: sclerosing, lytic and mixed. However, atypical cases account for about 25 per cent of the whole group and only the x-ray picture of the well developed sclerosing osteogenic sarcoma "is just about pathognomonic."

The principal roentgen characteristics obtained analyzing the ten reported cases of bone sarcoma of the skull following irradiation are described.

Consistently with the clinical findings, a soft tissue opacity was reported in most cases. This was represented by an external prominence or by a mass in the pneumatic cavities of the head. Such a picture obviously did not represent edema of the surrounding soft tissues, but an extra-osseous portion of the tumor mass.

Bone destruction was a second common feature. The absence of a bony wall of the pneumatic cavities, the presence of fragments of partially destroyed bone, and areas of rarefaction in the thickness of a cranial bone with cortical involvement have been reported. The margins of destruction when present were usually irregular or ill-defined as is typical of malignant lesions.

Periosteal reaction was also noted. The typical sun-ray spicules of bone reaction associated with marked sclerosis of the frontal bone were clearly demonstrated in one of the cases presented.

A complication such as pathological fracture was reported in one case of mandibular fibrosarcoma.[17]

An area of the skull that often defies early radiological evidence of neoplasia is represented by the temporal bone. In fact not until the tumor has extensively invaded the bone is the x-ray study of any significance. The differential diagnosis with a chronic inflammatory process of the mastoid is impossible on radiological grounds alone. In the case presented in this paper the x-ray findings of hazy opacity without definite bone destruction and moderate sclerosis was often interpreted as chronic mastoiditis. In these cases delay in diagnosis can be avoided only by histopathological examination of the "aural polyp or granulation tissue."

The progress and corresponding rate of growth or regress following therapy should be followed by serial films at regular intervals using the same projections and penetration in order to obtain comparable data.

PATHOLOGICAL ASPECTS

The importance of pathologic diagnosis in case of bone sarcoma following irradiation cannot be overemphasized. When the history, physical examination, radiologic study and laboratory determinations have been made, a surgical biopsy is essential for an accurate diagnosis and definitive therapy.

The biopsy should be done as a surgical procedure and taken from a representative area. Due to the pleomorphism of these tumors in different areas, the biopsy should include part of the extra-osseous tumor mass and underlying bone. Frozen sections have proved to be of limited value in cases of bone neoplasms. No proof has been elicited that a biopsy causes dissemination of this type of tumor through the blood stream. All available information should be given to the pathologist.

In discussing the histopathological aspects of osteogenic sarcoma of the skull following irradiation one is immediately faced with the problem of classification and identification of bone tumors. A universal classification of bone tumors has not yet been reached and the nomenclature is confusing.

Though "osteogenic" literally means "bone-producing," the expression "osteogenic sarcoma" was introduced by Ewing to designate a neoplasm derived from primitive malignant cells analogous to osteoblasts. "Osteogenic," in other words, relates to the histogenesis of these tumors derived from bone or bone-forming tissue and not necessarily to a bone-producing potentiality. In order to avoid misinterpretation Robb-Smith[39] and Thompson and Turner-Warvick[40] suggest using the term "osteoblast sarcoma" omitting "osteogenic." Since both of the cases herein reported arose in bone and produced osteoid and bone, they unquestionably should be classified "osteogenic."

Analyzing the histological study of the collected ten sarcomas of the skull following irradiation, nine were reported as osteogenic sarcoma and one as fibrosarcoma.

All of these tumors are characterized by very anaplastic cells with tremendous variation in size and shape. The nuclei vary in size and are fusiform, oval and polymorphic. The nucleoli are often prominent and the nuclear chromatin is deeply basophilic and arranged in irregular clumps. The mitotic figures are quite numerous.

Wolfe and Platt[18] described in their cases degenerating osteoblasts with pyknotic nuclei and vacuolization of cytoplasm as a possible expression of reaction to irradiation. The same picture was observed in the osteogenic sarcoma of the temporal bone reported in this paper.

In the osteogenic sarcomas multinuclear tumor giant cells were found in some sections, but they never predominated. Bony trabeculae surrounded by osteoblasts and osteoclasts were usually seen in the periphery of the tumor.

The intercellular stroma exhibited different types of tissues: fibrous, mucoid, hyaline, cartilaginous, osteoid and osseous. The amount and the admixture of these tissues varies in different parts of the tumor. Irregular islands of bone are surrounded by a narrow band of osteoid tissue. This osteoid tissue is formed directly by the malignant osteoblasts and represents the malignant counterpart of normal subperiosteal new bone formation.

The amount of cartilaginous tissue varies. In some sections only islands of abortive cartilage can be found. In other cases a section may give the impression of a chondrosarcoma. In our case of osteogenic sarcoma of the frontal bone, superficial sections revealed chondrosarcoma with areas of myxomatous degeneration and a few areas of calcification; however, deeper sections revealed a typical osteoblast osteogenic sarcoma.

Two kinds of blood vessels were described by Ewing[41] in osteogenic sarcomas: the blood vessels of the involved bone that are appropriated by the tumor and the blood sinuses peculiar to the tumor and surrounded by neoplastic cells. This second type of vascular spaces lined by tumor cells was also noted in our case involving the frontal bone.

Histopathologically, it should be emphasized that though malignant osteoblastic cells may appear differentiated in producing osteoid tissue, osteoblast osteogenic sarcoma is a highly malignant tumor of bone.

THERAPEUTIC ASPECTS

It is agreed that the treatment of osteogenic sarcoma in general has been very disappointing. Several factors have been considered and are summarized: age of the patient, pre-existing bone affections, site and extent of involvement, radiographic appearance, histological feature and grading of the malignancy.

The patients under 10 and over 40 seem to carry the worse prognosis.[42] Pre-existing bone conditions such as osteitis deformans, fibrous dysplasia and cysts are often associated with the osteolytic type of sarcoma and respond poorly to radiation therapy.[42-44] The site and extent of involvement relates to the possibility of resection and effective radiation. Osteogenic sarcomas with radiological evidence of predominant bone reaction have a better prognosis than those with prevalence of destruction. A high degree of cellularity, anaplasia of cells and nuclear activity suggest a poor prognosis.

In the treatment of primary osteogenic sarcomas of the long bones most authors have emphasized preoperative irradiation followed by amputation.[21,42,45]

In osteogenic sarcomas of the skull following irradiation, the osteolytic type definitely predominates, probably because of the origin in previously abnormal bone. Besides, these tumors are usually very radioresistant in relation to their origin from irradiation. Finally, the site of involvement makes an effective dosage with radiation extremely hazardous.

Radical surgical resection of these tumors when feasible is the treatment of choice. Of the ten collected cases two are reported alive and well: one[18] a year after rhinectomy, the other[16] four years after maxillary resection. Two cases of osteogenic sarcoma involving the mandible showed intracranial involvement within a year after hemimandibulectomy and resection of the surrounding soft tissues. Kaae and Glahn[17] do not report any follow-up of their fibrosarcoma of the mandible after hemimandibulectomy.

In the cases of osteogenic sarcoma of the ethmoid, exenteration of the orbit and resection of the surrounding bony structures proved to be inadequate. Early evidence of residual and intracranial involvement occurred. Two cases did not receive any treatment and the tumor followed its destructive and invasive pattern. In the case of osteogenic sarcoma of the temporal bone, local persistence four months after a previous wide mastoidectomy was removed by a more radical resection, but the patient died accidentally five months later.

X-ray therapy or radium can be useful as a palliative measure to decrease the swelling and pain when surgery is not possible. In Jones' case, teleradium and radium implantation for a total dosage of 17,830 r was applied over a period of six months; however, the patient was never free of disease and died with invasion of the base of the skull.

The results to date are not encouraging. The survival rate is too small and for too brief an interval. As shown by Coley and Harrold,[46] a survival of five years is not a critical test of cure, since evidence of osteogenic sarcoma was found up to 14 years after treatment. It is the opinion of the authors that wide surgical resection when feasible should be the treatment of choice of osteogenic sarcomas of the skull following irradiation. Due to the extremely small series of cases and short observation after treatment no final conclusion is possible at present.

SUMMARY

Two cases of postirradiation osteogenic sarcomas of the skull bones are reported.

The first developed in the temporal bone three and a half years after the irradiation of a postauricular keloid and was surgically resected. The second developed in the frontal bone ten years after the irradiation of a retinoblastoma and was inoperable.

Similar cases reported in the literature are reviewed. The role of radiant energy in the production of sarcomatous changes in bone is discussed analyzing the most important etiologic factors. The clinical, radiological, pathological and therapeutic aspects of osteogenic sarcomas of the skull following irradiation are analyzed in detail.

CONCLUSIONS

1. Etiologically, the relatively young age of the patients, the minimum dosage of 3,000 r, the prolonged mode of irradiation and a latent interval of at least three years are important factors in the development of osteogenic sarcomas of the skull following irradiation.

2. These neoplasms have no definite characteristic clinical manifestation and challenge early diagnosis with their rapid growth. A suspicion of malignant degeneration should exist if a localized swelling or mass develops in a region of previous irradiation particularly if associated with skin alterations, pain and functional disturbances.

3. Osteogenic sarcomas of the skull following irradiation have no radiological feature that can justify a specific diagnosis. The main characteristics are the presence of a soft tissue mass, bone destruction with cortical involvement, periosteal reaction and eventually complicating fractures. An x-ray study is fundamental to confirm the

clinical impression, location and extension of the soft tissue prominence; it may offer a diagnosis of malignant tumor and guide the biopsy of the neoplasm. It is of utmost importance in the follow-up of these disorders.

4. Osteogenic sarcoma designates a highly malignant neoplasm derived by cells analogous to osteoblasts. Its essential feature is the formation of osteoid tissue directly by the malignant osteoblasts with no intermediate fibrous or cartilaginous matrix. The presence of cartilage or giant cells does not exclude the diagnosis. No definite histological characteristic could be demonstrated in the osteogenic sarcomas of the skull following irradiation.

5. Therapeutically, no definite conclusion is possible at present. Wide surgical resection appears to be the treatment of choice when feasible. Palliative irradiation may be of relative significance.

6. Extensive and prolonged irradiation therapy for benign conditions amenable to radiation should be avoided, but this should not deter from the judicious use of radiation when indicated.

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LXXVI

ASTROGLIA AND PERIVASCULAR STRUCTURES OF THE HUMAN OLFACTORY BULB

A STUDY WITH SILVER-CARBONATE

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Knowledge of the glia of the olfactory bulb is limited to the classical studies of Cajal[1] who described astroglia in the olfactory bulb of the cat and to de Castro[2] who investigated the histogenesis of glia in embryos and in newborn animals. There is no description of the glia of the olfactory bulb in man.

In the present investigations human tissue was used; the various types of astroglia peculiar to the olfactory bulb and their relationship to blood vessels were studied.

The tissue obtained post mortem was fixed in brom-formalin, cut on the freezing microtome at 10-15 microns and was treated with numerous variants of the silver-carbonate technique of del Rio Hortega modified by Scharenberg[3] and Liss.[4]

In a previous investigation we outlined that four layers can be distinguished in the human olfactory bulb:[5] 1) the fila olfactoria, 2) the layer of glomeruli, 3) the layer of ganglion cells and 4) the olfactory tract fibers. The first layer contains only a few astroglial cells. In the second (glomerular) layer giant astrocytes with long, thick processes form a dense periglomerular network (Fig. 1). In the third (ganglionic) layer there are numerous astrocytes with oval bodies and radiating processes which vary in thickness and length (Fig. 2). In the fourth (fiber tract) layer there are scattered astrocytes with oval bodies and numerous fine and long processes most of which run parallel to nerve fibers (Fig. 3). The astrocytes shown in Figures 1 and 3 represent types commonly found in the central

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From the Laboratory of Neuropathology, Neuropsychiatric Institute, University Hospital, Ann Arbor, Michigan. (Grant-in-aid from the U. S. Department of Public Health and Welfare 418 C-2.)

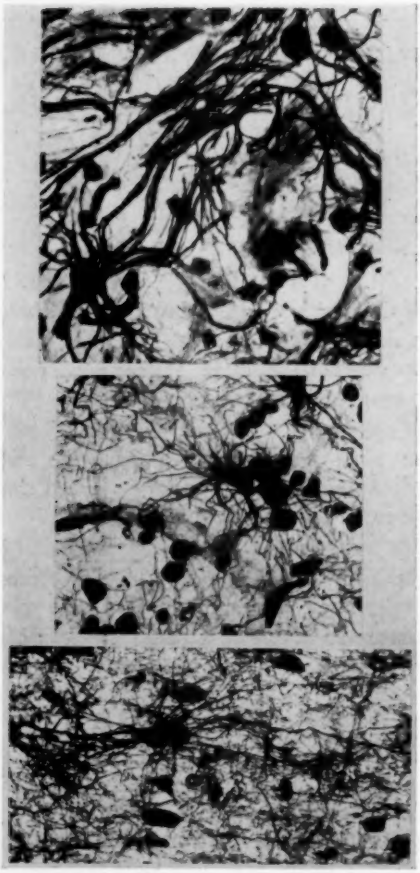

Fig. 1.—Large astrocyte from glomerular layer. Astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Fig. 2.—Astrocyte with radiating processes from ganglionic layer. Astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Fig. 3.—Astrocyte from the layer of the olfactory tract fibers; the processes run mostly parallel to the nerve fibers. Modified astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

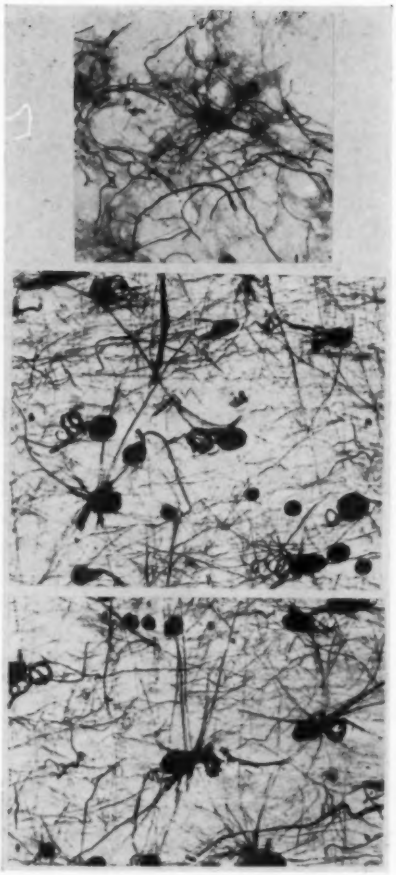

Fig. 4.—Astrocyte with basket-like end structures; ganglionic layer. Astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Figs. 5 and 6.—Astrocytes with corkscrew-like formations; layer of the olfactory tract. Astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

nervous system (Cajal[6]). These elements form a dense glial network which supports all cell structures and vessels of the bulb (Fig. 8).

There are in addition two elements which deviate from typical astrocytes: one of them has an oval body and radiating processes some of which form numerous loops; this cell is peculiar to the ganglionic layer (Fig. 4); the second is present in the layer of the olfactory fibers: these elements have round or oval bodies and several long and straight processes; others form spirals (Figs. 5 and 6).

The perivascular structures of the olfactory bulb are composed of glia and mesodermal elements and contain at least five different types of cells and a nerve plexus.

1) *Perivascular astrocytes.* There are two types: a) astrocytes with numerous processes which coil around closely adjacent vessels, and b) astrocytes with long processes some of which surround blood vessels while others contribute to the glial matrix (Fig. 8).

2) *Perivascular oligodendroglia.* These elements are located near the capillary or lie directly on its wall; they have round bodies and one or more processes which form a distinct fibrillary plexus on the vessel (Fig. 9).

3) *Perivascular cells* of undetermined origin, possibly glia, with elongated bodies and radiating processes which give rise to a dense network of branching perivascular fibers (Fig. 10).

4) *"Transitional cells"* with oval bodies and two or more processes which seem to form an integral part of the vessel wall. These elements resemble both the perivascular glia and the pericytes (Fig. 11).

5) *Pericytes.* There are two types, both apparently lying directly upon the endothelium: one is characterized by barbed processes (Fig. 12), the other by a coarse network (Fig. 13).

6) *Vascular nerves* form a delicate perivascular plexus (Fig. 14).

COMMENT

A) The astrocytes of the olfactory bulb are of several morphologic types which vary according to the structures they support: a) large periglomerular astrocytes with numerous long processes

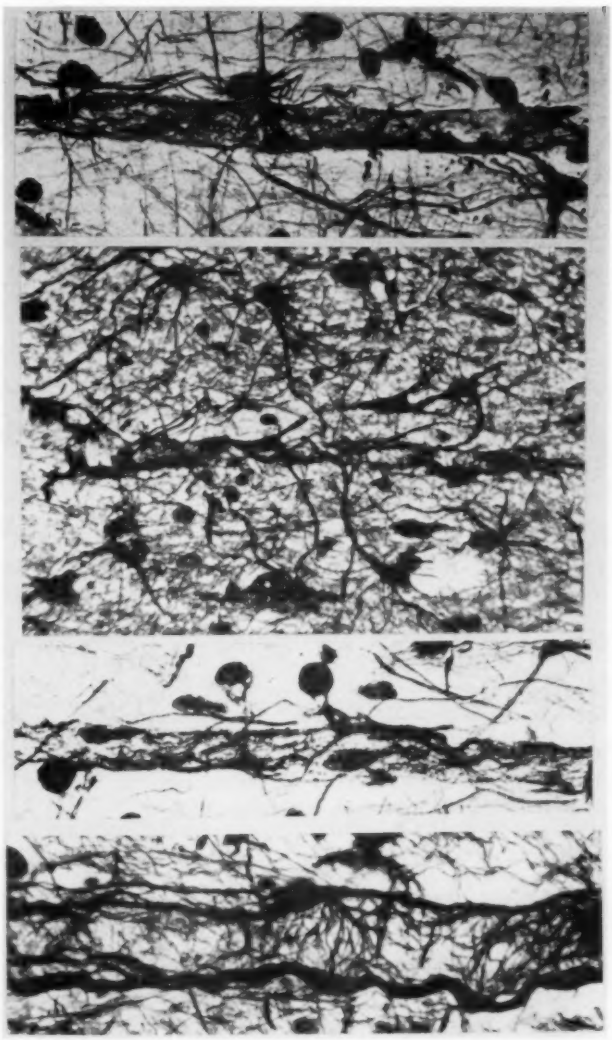

Fig. 7.—Perivascular astrocytes located close to the vessel. Astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Fig. 8.—Perivascular astrocytes connecting the vessel with suckerfoot. Astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Fig. 9.—Oligodendroglia cells forming perivascular network. Oligodendroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Fig. 10.—Perivascular cell with numerous processes (probably glia). Modified astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

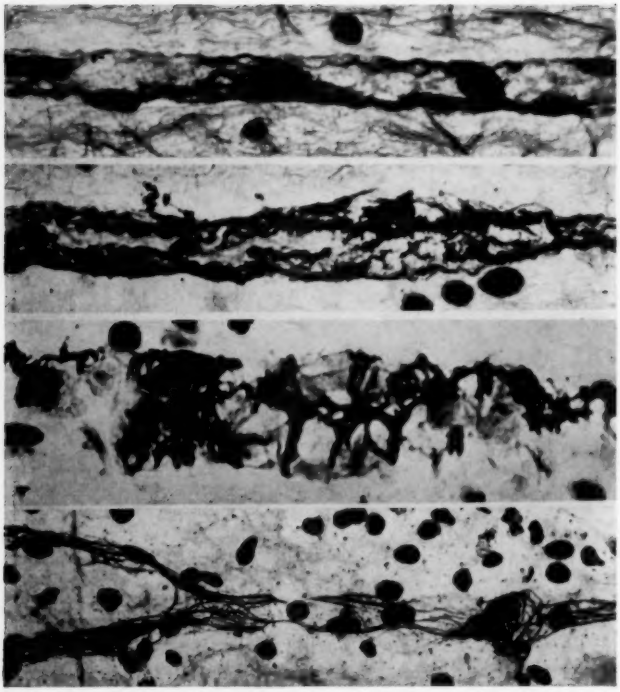

Fig. 11.—Perivascular cells of transitional type. Modified astroglia impregnation. Photomicrograph. Zeiss Neofluar 40x.

Figs. 12 and 13.—Pericytes. Triple impregnation. Photomicrograph. Zeiss Neofluar 40x.

Fig. 14.—Perivascular nerve plexus. Double impregnation. Photomicrograph. Zeiss Neofluar 40x.

around the glomeruli, b) smaller astrocytes with radiating processes in the ganglionic layer; c) astrocytes among the nerve fibers of the olfactory tract; these elements have very long processes parallel to the nerve fibers. Two other types of astrocytes belong to a group which have not been previously recognized. The main characteristics of these elements are basket- or corkscrew-like structures formed by their processes. d) One of these varieties is in the ganglionic layer, the other e) among the fibers of the olfactory tract. De Lochand described what he called "Terminations annulaires libres de fibres nevrogliques" or free rings of glial fibers but did not mention their

origin. These rings possibly represent a part of the spirals of astrocytes illustrated in Figures 5 and 6.

B) In the perivascular structures there can be distinguished six different elements. 1) Perivascular astrocytes which lie on the vessel and form a dense network around it, or lie at some distance from the vessel to which they attach by a long process with a "sucker foot." These cells form the dense network (glial matrix) of the bulb. 2) The perivascular network is augmented by processes of oligodendroglia. 3) The nature of some of the elements of the perivascular structures is still in doubt. These perivascular cells (Fig. 10) which we consider to be glia are interpreted by Buño[8] as endothelial elements (endothelios vasculares), but this concept is not satisfactory because the cells seem to lie on the vessel wall and above the endothelial layer. 4) Elements described as "transitional types" resemble glia, pericytes and endothelial cells; their exact nature is still obscure. 5) Two types of pericytes (Zimmermann[9]) are a constant finding: a) barbed type placed in long parallel chains, and b) pericytes with coarse fibers which are mostly placed perpendicular to the vessel.

6) The perivascular nerve plexuses which accompany the blood vessels are formed by a network of delicate nonmyelinated nerve fibers.

SUMMARY

1) Five types of astrocytes are described in the human olfactory bulb: a) periglomerular astrocytes, b) elements with radiating short processes, c) cells with delicate parallel processes, d) elements with basket-like processes and e) large cells with corkscrew-like processes.

2) The perivascular structure contains six elements: a) astrocytes, b) oligodendroglia, c) perivascular glia of undetermined type, d) "transitional cells," e) pericytes and f) nerve plexuses.

UNIVERSITY HOSPITAL

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LXXVII

PARALYSIS OF THE VOCAL CORD

REPORT OF A CASE OF UNILATERAL PARALYSIS WITH INADEQUATE AIRWAY

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Unilateral vocal cord paralysis is not usually considered a serious condition. A paralyzed vocal cord may assume a median line position and if this occurs, the voice is unchanged, but hoarseness is noted if the cord assumes a lateral or so-called paramedian or cadaveric position. An inadequate airway is usually seen when there is a bilateral abductor vocal cord paralysis with the cords assuming a median line position. To my knowledge the presence of an inadequate airway with a unilateral vocal cord paralysis has not been previously reported. Recently I have had occasion to see two patients with unilateral vocal cord paralysis with inadequate airway, one of which was treated surgically for this condition with an excellent result.

Various lesions either central or peripheral may produce a vocal cord paralysis. The paralysis may result from a peripheral neuritis secondary to acute infectious diseases, diphtheria, typhoid fever, syphilis or drug poisoning. It may result from bulbar poliomyelitis or tabes. The condition has been reported as a complication of acromegaly. It may follow injury to the neck. Encroachment on the recurrent laryngeal nerves by a mediastinal tumor, an enlarged heart, tuberculous lesion, syphilitic lesion, enlarged thyroid gland or direct involvement by malignancy of the thyroid gland may also produce this complication. Fixation of the arytenoid cartilage at the cricoarytenoid joint may occur in some instances from non-specific causes, others by specific infections such as blastomycosis as observed by the author in one case recently reported.[1] In a recent report by Cunning,[2] the toxic and idiopathic groups causing vocal cord paralysis made up more than one-half of the cases (53 per cent of the series reported).

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Presented before the North Central Clinical Society, Dearborn, Michigan, May 12, 1956.

In patients with vocal cord paralysis with inadequate airway that I have observed, most have resulted following thyroid surgery. Respiratory emergencies during thyroidectomy are probably the result of a bilateral abductor vocal cord paralysis rather than of a tracheal collapse. Some patients have been observed with a very small glottic opening who have been accustomed to the restricted airway, developing dyspnea and stridulous breathing, on exertion associated with acute upper respiratory infections, which make it advisable to perform a tracheotomy. An occasional patient is observed who has the vocal cords on different levels, so that the glottic opening, although constricted, allows for normal respiration and limited activities.

SURGICAL TREATMENT

In patients who have a vocal cord paralysis whether bilateral or unilateral, and who have an inadequate airway or who have required tracheotomy and have shown no improvement within six months following the onset, an attempt to correct or improve this condition should be considered. Some patients may prefer a valvular tracheotomy tube, such as designed by New or Tucker, to surgery. Various operations applying different approaches or technique have been reported with varying degrees of success. Irrespective of the surgical procedures selected in the treatment of vocal cord paralysis with inadequate airway, one strives for two objectives: first, the establishment of an adequate airway; and second, the preservation of the voice. These two objectives require conditions diametrically opposed to one another. An adequate airway requires separation of the vocal cords, whereas a normal voice requires close approximation of the vocal cords. The problem in the management of these patients is to move one paralyzed vocal cord laterally far enough to create an adequate airway without moving it so far laterally as to destroy the voice. All interested in this type of corrective surgery are in agreement that of the two objectives, the establishment of an adequate airway is the more important.

In 1932 Hoover[3] reported successful results with submucous resection of the vocal cords. In recent years renewed interest in the treatment of abductor vocal cord paralysis followed King's report in 1939.[4] This consisted in a lateral displacement of the vocal cord by disarticulation of the arytenoid cartilage and fixing it in a lateral position. Various modifications followed his presentation. More recently, the author has reported on the transoral intralaryngeal approach for arytenoidectomy for the treatment of abductor vocal cord paralysis.[5-10]

REPORT OF A CASE

A 40 year old housewife was seen in my office on September 12, 1955. She stated that on August 19, 1954 she had undergone a thyroidectomy following which she noted marked weakness of her voice. Within the past three to four months she had developed increasing difficulty with her airway. Difficulty was especially noticeable on exertion.

Examination revealed a unilateral vocal cord paralysis involving the right vocal cord which extended over the median line towards the opposite side. The patient had a small larynx, especially in the anterior posterior direction. At the widest part of the glottic chink there was only a 3 mm opening. This patient had been examined from time to time by laryngologists elsewhere and it was their opinion that she had an inadequate airway. I was also in agreement with the above. A right-sided transoral intralaryngeal arytenoidectomy was advised. This was carried out December 8, 1955. Immediately preceding the arytenoidectomy, a tracheotomy was done under local anesthesia following which an arytenoidectomy was carried out on the right side under intravenous pentothal sodium. The tracheal cannula was occluded on the eighth postoperative day and the patient was dismissed from the hospital on the following day. The tracheal cannula was removed ten days later. She was again seen in my office on March 30, 1956, at which time the tracheal stoma had completely healed over and the patient was noted to have a 5 mm opening between the vocal cords at its widest angle. There was no difficulty with respiration and the voice, although slightly weak, was adequate.

CONCLUSIONS

Since 1945, 55 cases of bilateral abductor vocal cord paralysis with inadequate airway have been treated surgically by the author. One case of unilateral vocal cord paralysis with inadequate airway is reported treated by transoral intralaryngeal arytenoidectomy. There are available at the present time reports from various laryngologists all over the country of over three hundred cases of bilateral abductor vocal cord paralysis which have been treated surgically by the transoral approach. The results have been excellent in 96 per cent of the cases.

The possibility of vocal cord paralysis as a complication of thyroid surgery should always be kept in mind. I would like again to urge the importance of a preoperative as well as an immediately postoperative examination of the larynx in patients undergoing thyroid

surgery. It should be borne in mind that in an exceptional case an inadequate airway may result from a unilateral vocal cord paralysis.

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LXXVIII

REDUCED BLOOD VOLUME OCCURRING IN OTOLARYNGOLOGIC PATIENTS

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Many surgeons believe that ordinary determination of the blood hemoglobin, blood erythryocyte count, hematocrit, and plasma protein concentration is an adequate measure of a patient's blood volume and total hematologic constituents. To put it another way, they think that if these values in any specimen of blood are normal, there is no deficiency in the total amount of circulating plasma volume and protein and erythryocyte mass.

Unfortunately they are wrong. Failure to recognize the distinction between ordinary peripheral blood determinations and the values obtained by total blood volume determinations has caused fatalities from shock either during an operation or in the early postoperative period as well as increased postoperative morbidity. Anesthesiologists have become acutely aware of the relationship between reduced blood volume and instability of blood pressure during surpical operations. At the Ohio State University they may refuse to anesthetize certain patients whose blood volumes have not been determined preoperatively.

Numerous investigators have shown that in states of chronic infection, carcinoma or malnutrition there may be a great reduction in circulating blood volume. The reduction roughly parallels the patient's weight loss and may amount to as much as 60 per cent.[1] In malnourished patients, total blood volume may approximate the assumed standard for observed weight. However, in patients who have lost weight recently, it is a mistake to use the current weight to calculate the blood volume. Rather, the patient's customary weight should be used, unless he is unusually obese or tall and thin. Under such circumstances standard weight tables for sex, age and height are used.[2] In patients who have lost weight gradually over a period of six months or a year, the previous normal weight is not a reliable

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index to the blood volume because in these patients there has actually been a closure of small vessels permanently reducing the vascular reservoir.

The hemoglobin deficit is perhaps the most important deficit since it is the hemoglobin which carries oxygen. Also of major importance is a deficit in total serum albumin since such a deficit affects total circulating volume and therefore susceptibility to shock.

In general, patients with blood volume deficits of 500 to 1,000 milliliters or more are considered questionable surgical risks. Replacement of the deficit in blood volume should be accomplished before the time of surgical intervention. Unless the patient is given transfusions, the restitution of red cell volume occurs very slowly. A rule of thumb is to consider every ten pounds of recent weight loss to be associated with loss of 500 cc blood volume. Even in cardiac patients it is practical to restore the blood volume by transfusion to the standard value for the patient's usual weight. Overloading of the vascular reservoir and significant hemoconcentration apparently does not occur if care is used and undue haste avoided.

A determination of plasma volume, using the Evan's blue dye, T-1824, has become an accepted laboratory procedure in clinical investigation. More recently human serum albumin has been iodinated with radioactive iodine 131 and used to determine plasma volume in man.[3,4,5] Indeed, such use of radioactive serum albumin offers several advantages over the dye method. The accuracy of repeated tests is not influenced by previous injections, there is no possibility of staining the patient's skin, jaundice does not interfere with the test, and fasting is not required.

Otolaryngic illnesses seldom contribute to severe deficits of blood volume such as are seen on general surgical services where gastrointestinal malignancies and postoperative abdominal complications are common and interfere seriously with nutrition. Nevertheless, the otolaryngologist who performs operations for the cure or palliation of malignant conditions, especially in the oral cavity and esophagus, may encounter such cases. Poorly nourished patients who have lost weight because of infection may also develop a blood volume deficit. Chronically ill patients whose wounds heal slowly are also suspected and deserve blood volume studies.

During the past year, several cases of reduced blood volume have been recognized on the otolaryngological service at University Hos-

pital. Some were associated with malignancy of the oral cavity; one was due to a severe lye burn with associated sepsis and malnutrition. Some of the cases were recognized preoperatively and were treated by transfusions of from two to four pints of blood. The case reported in this paper went unrecognized until a state of shock developed in the postoperative period. This case is reported in detail to emphasize that every otolaryngologist who treats malnourished patients should be aware of the importance of blood volume determinations. He should understand the fallacy of accepting arbitrarily the routine blood count, with or without hematocrit and plasma protein values, as representative of the same components when expressed as total circulating amounts. If blood volume determinations are not available at a particular hospital, then it is advisable to treat a patient with recent weight loss (due to malignancy or infection) by giving blood transfusions in the ratio of 500 cc whole blood for each ten pounds' weight loss.

REPORT OF A CASE

A 50 year old white man was admitted to University Hospital complaining of total dysphagia for one week and loss of 30 pounds' weight during the previous month. He was known to be mildly diabetic, but otherwise the history was noncontributory.

Roentgenograms made at another hospital had shown a large filling defect of the cervical esophagus. A roentgenogram of the chest was negative. The entire physical examination was negative except for evidence of recent weight loss, pooling of secretions in the pyriform recesses, and absence of laryngeal crepitation. No tumor or lymph nodes could be felt in the neck.

An esophagoscopy was attempted, but the esophagoscope could not be passed beyond the cricopharyngeus because a mass compressed the esophageal lumen at this level. Repeated specimens for biopsy were taken through a laryngoscope, but a report of malignancy could not be obtained.

An exploratory operation was carried out June 13, 1955, through a lateral pharyngotomy incision. A biopsy of the mass in the upper cervical esophagus was reported on frozen section to be poorly differentiated squamous cell carcinoma. At the same operation a total laryngectomy, cervical esophagectomy, and subtotal thyroidectomy were carried out, and a pharyngostomy, esophagostomy, and tracheostomy were created. Blood loss was measured at 500 cc, and an equal amount of blood was transfused.

The postoperative course was smooth, and the three cervical stoma healed well. On the fifteenth postoperative day, a second operation was performed to elevate a pedicle flap from the anterior chest wall. The patient was discharged from the hospital 33 days after admission.

The patient was fed at home by intubation of the esophageal stoma. While he was awaiting hospitalization for advancement of the pedicle flap, his weight dropped from 125 to 119 pounds (his normal weight was 150 pounds). He complained of great tiredness and listlessness and even seemed disinterested in living.

When he was readmitted to University Hospital, his diabetes mellitus was out of control, and he spilled large amounts of sugar despite insulin therapy. A chest roentgenogram was again negative. Routine blood determinations were as follows: rbc: 5.74 million; hemoglobin: 16.4 grams; wbc: 11,000; differential count: normal; total protein: 8.3 grams with albumin 4.9 grams and globulin 3.4 grams. Serum electrolyte studies were normal.

On the third day of his second admission to the hospital the patient slipped into a state of shock. His blood pressure dropped to 78/54 and his pulse was 120. Neosynepherine was given intravenously to restore the blood pressure and when it was gradually discontinued the patient lapsed again into shock. When the stimulant was readministered, the blood pressure returned to 90/60, although the patient was comatose at least part of this time. Again all routine blood determinations were repeated and were found to be within normal limits. On August 6, 1955, three days after the onset of his shock-like state, the patient received two units of serum albumin. His condition improved moderately, and supportive therapy for maintaining blood pressure became unnecessary.

On August 8, 1955, after the patient had received two units of albumin a blood specimen was run for hemoglobin, serum proteins and red blood count. Although these values were all within normal limits, a blood volume determination made simultaneously indicated that the patient was in deficit of red cell mass equal to five units of blood. The patient was immediately transfused with 2,500 cc of whole blood. His condition improved dramatically. He got out of bed for the first time in two weeks. His skin wound began to heal, and the diabetes mellitus came under control so that it was possible to stop insulin. A subsequent blood volume determination was normal.

The esophagus has been reconstructed, and the patient swallows normally.

Here is a summary of the hematologic data at the time of the two hospitalizations:

DATE	WBC	RBC	HEMOGLOBIN	HEMATOCRIT	SERUM PROTEIN
6-7-55	12,500	5.26M	15.5	39%	6.8
7-19-55	14,900	5.74M	16.4	47%	8.3
8-3-55	19,600	4.7 M	13.6	50%	8.2
8-6-55	14,200	4.8 M	14.0		8.0

8-6-55 THEORETICAL BLOOD VOLUME		EXPERIMENTAL DETERMINATION	DEFICIT
Whole Blood Volume	5220 ml	3820 ml	1400 cc
Plasma Volume	2770 ml	2270 ml	500 cc
Red Cell Mass	2450 ml	1438 ml	1012 cc
Hematocrit	49%	37.4%	

SUMMARY

Significant reduction in blood volume occurs in patients with recent loss of weight because of infections or malignancy. If unrecognized it may lead to chronic shock or even operative fatalities. The usual blood determinations such as hemoglobin concentration, red blood cell count and hematocrit may not correlate with the patient's actual total amount of the same constituents expressed as total circulating hemoglobin, etc. A case is presented to illustrate how shock may develop as a result of reduced blood volume.

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LXXIX

ANESTHESIA OF THE CHEEK: AN EARLY SIGN OF CARCINOMA OF THE MAXILLARY SINUS

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Malignancy of the paranasal sinuses has been reported to account for approximately 1 per cent of all malignant disease. Its infrequency makes the accumulation of large series for statistical purposes difficult, although reports covering in excess of 100 cases have come from some of the larger clinics, especially in countries where cases of this nature are channelled to specific centers.

Sinus malignancy occurs most frequently in the 50 to 70 year age group; is only slightly more common in males, varying from 1 : 1 to 2 : 1 in different series; and involves the antrum at least 5 to 7 times as frequently as the other sinus compartments combined; sphenoid or frontal sinus carcinoma is very rare. Squamous cell lesions account for nearly 90 per cent of antral carcinomas; the remainder consist of adenocarcinomas, cylindrical cell carcinomas, transitional cell carcinomas, mucoepidermoid carcinomas, and undifferentiated carcinomas. Sarcomata do occur, but rarely.

The prognosis of antral carcinoma depends on early diagnosis, the location and extent of the lesion, the histological type of the malignancy and the therapy given. It is only through the earlier diagnosis and the development of newer treatment techniques that there is hope of improving the five-year cure rate, which at present ranges from 10 to 45 per cent[1] according to different series and different material.

Unfortunately, the earliest symptoms of cancer of the antrum are protean, resembling those of chronic sinusitis; and it is not until

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extension of the tumor through the bony confines of the antrum occurs, causing swelling of the cheek, palate or orbital region and x-ray evidence of bone destruction, that the diagnosis is entertained clinically. The commonest initial symptoms of antral carcinoma in approximate order of their frequency are:

Swelling: Involving the cheek, palate, or orbital region (suggestive of erosion through the bony wall, but occurring sometimes without x-ray evidence of this, and probably attributable to secondary inflammation).

Pain: Involving the cheek, side of the face, upper alveolar ridge or teeth.

Nasal obstruction: Due to a secondary sinusitis, and sometimes due to tumor extension into the nasal cavity or the nasopharynx or both. Occasionally nasal polyps of benign appearance prove to be malignant on histological examination. This group represents a relatively early diagnosis and offers a better prognosis.

Epistaxis: Usually an intermittent blood-streaked discharge. If diagnosis can be made at the stage when epistaxis represents the only symptom, prognosis is usually much more encouraging.

Approximately 90 per cent of cases show evidence of bone destruction at the time of their initial sinus x-rays. We have recently seen a patient having antral carcinoma whose initial complaint in the out-patient department was numbness and pain of the cheek, and whose initial x-rays, including stereoscopic views, showed a cloudy antrum without any evidence of bone destruction. This prompted us to review the charts of 38 cases of antral carcinoma in which the primary diagnosis was made at the Columbia-Presbyterian Medical Center during the ten year span, 1946 to 1955. Six patients complained of numbness of the cheek at the time of admission; two of these were not counted because they had had previous sinus surgery (Caldwell-luc) which may have accounted for the numbness. Thus, out of the 38 cases, 4 presented themselves with numbness of the cheek. Of these 4 cases, 3 showed no evidence of bone destruction at the time of the initial x-rays.

McMahon[2] recently reported a case of carcinoma of the maxillary sinus in a male of 20, whose chief complaint was numbness of the

cheek of four weeks' duration, followed by marked swelling of the cheek and orbit. X-rays in this case revealed a density of the antrum, but there was no mention of bone destruction. A preoperative diagnosis of acute purulent hyperplastic maxillary and ethmoid sinusitis was made; but at operation the sinus was filled with friable red mucosa, which on section proved to be a poorly differentiated squamous cell carcinoma.

Pollack[3] presented three cases of antral cylindroma, a tumor characterized by a tendency to perineural extension; and it is interesting that all three cases had numbness of the cheek.

Numbness, anesthesia, and hypesthesia of the second division of the V cranial nerve (V2) has been reported as one of many other symptoms in antral carcinoma by different authors; however, because the frequency of it in this small series was surprisingly high, and because this finding aided in making an earlier diagnosis, we present these four cases. In Case 1 hypesthesia of the cheek prompted us to explore the antrum.

REPORT OF CASES

CASE 1. A 52 year old white female was first seen in the outpatient department on May 21, 1955, with a chief complaint of pain and numbness over the left cheek. Eight months previously a left upper molar tooth had been extracted because of pain without relief, and during the interim the left antrum had been irrigated elsewhere some 13 times, productive of purulent, occasionally blood-streaked material. Physical examination revealed anesthesia of the left cheek, and the left antrum was dark to transillumination. Stereoscopic sinus films showed slight clouding of the left antrum without any evidence of bone destruction. Suspecting malignancy, a left Caldwell-luc was performed revealing a tumor mass, whitish-gray in color, filling the entire antrum, which proved to be a poorly differentiated squamous cell carcinoma.

CASE 2. A 52 year old Negro woman was first seen in the outpatient department on January 11, 1947, with a chief complaint of swelling and numbness of the right cheek of three weeks' duration. Physical examination revealed a slightly tender diffuse swelling of the right cheek and polypoid tissue in the right middle meatus. The right antrum was dark on transillumination; x-rays showed diffuse clouding of the right antrum without evidence of bone destruction. Aspiration of the swelling through the canine fossa produced 5 cc of bloody

material which on section revealed an undifferentiated squamous cell carcinoma.

CASE 3. A 55 year old white female was first seen in the outpatient department on June 17, 1949, with a chief complaint of left-sided facial pain of three months' duration, associated with numbness over the left cheek and diminished hearing acuity on the left. During the week prior to her clinic visit she had had two brief episodes of epistaxis. Examination revealed a polypoid mass in the left middle meatus and hypesthesia of the left cheek in the distribution of V2. Her initial x-rays showed diminished translucence of the left antrum, and in the Waters view it was difficult to make out with certainty the lateral wall of the left antrum. Two polyps were removed from the left middle meatus, histologically revealing a well differentiated squamous cell epithelioma.

CASE 4. A 55 year old white male presented himself in the outpatient department on July 4, 1948, with a chief complaint of soreness around the right eye of one week's duration. He also complained of numbness of the right upper lip. Physical examination revealed edema of the right lower lid, and extending over the cheek and side of the face. The right eye was displaced forwards and upwards by an ill-defined mass in the floor of the orbit. The right antrum and frontal sinus were opaque to transillumination; x-rays showed densely clouded paranasal sinuses; no evidence of dehiscence of the bone could be seen on the x-rays. Biopsy of the orbital mass revealed a moderately well differentiated squamous cell carcinoma.

SUMMARY AND CONCLUSIONS

Any hope of improving the five-year cure rate for antral carcinoma lies in the earlier diagnosis and the development of newer treatment techniques.

Carcinoma of the antrum is seldom diagnosed before there is x-ray evidence of destruction of the bony antral walls.

Of the 38 cases in this series, 4 had numbness or hypesthesia of the cheek, or both, indicating involvement of the second division of the V cranial nerve. Three of these 4 cases had x-rays which did not show evidence of bone destruction.

The cheek should be examined clinically for the presence of anesthesia in any patient with a history of persistent pain, numbness, or swelling of the upper jaw.

X-rays failing to show bone destruction should not be accepted as proof that an antral malignancy does not exist.

The finding of anesthesia of V2 should suggest antral malignancy, even in the face of x-rays which fail to show any evidence of bone destruction.

Exploration of the antrum is justified and advisable under such circumstances.

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LXXX

CAROTID BODY TUMOR OF THE TRACHEA

GLOMUS JUGULARIS TUMOR, TYMPANIC BODY TUMOR, NONCHROMAFFIN PARAGANGLIOMA

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Primary tumors of the trachea are not a common lesion. The most frequent site of the tumor in the adult has been in the lower third of the trachea; the second most common site in the upper and the least frequent in the middle third. Gilbert et al.[1] reviewed 546 cases of primary tracheal tumors in infants and adults collected from the literature, which did not include any cases of carotid body tumors in the trachea. Rosenwasser,[2] in 1945, described a tumor which filled the middle ear and extended into the mastoid process without any demonstrable involvement of the carotid body in the neck. He regarded this as a carotid body tumor, or glomus jugularis. The same author[3] has reported further cases and discusses embryological developments which may lead to carotid body tissue being found in locations removed from the carotid body, and being therefore primary. The presenting symptom in the case reported here was that of bleeding which occurred suddenly with no symptoms of pain or any obstruction to respiration. To the best of our knowledge this is the first case reported as occurring in the trachea.

REPORT OF A CASE

Mr. S.B., aged 45, was first seen at Mt. Sinai Hospital, Hartford, Connecticut, on March 21, 1953, where he had been admitted because of sudden hemoptysis after a paroxysm of cough. There was no history of any previous hemoptysis; but there was a past history that for many years patient had complained of pain and discomfort with stiffness of the muscles in the back of his neck, more particularly on the left side. No definite diagnosis had ever been made. At one time a diagnosis of syringomyelia had been made and some treatment had been instituted, but this had occurred ten years before and the patient was rather vague as to the type. There was no family history of hemoptysis except for a maternal uncle who had "coughed and spit blood for many years." Interestingly enough, this uncle had been

under the care of my father, Dr. Burnhardt Zeman, who on examining his old records informed me that the patient had had repeated bouts of hemoptysis over a period of 15 years, during which time no specific diagnosis was ever made. He was treated symptomatically and lived to the age of 70. In October of 1950, I saw Mr. A.B., the father of Mr. S.B., because of a complaint of fullness in his throat and some difficulty in swallowing. On indirect laryngoscopy a large, yellowish tumor mass was seen at the introitus of the esophagus on the left side. This was subsequently removed via direct laryngoscopy and proved to be a non-malignant cyst. At the present time (1956) Mr. A.B., the father, is alive and well and there has been no recurrence of this tumor.

On March 22, 1953, under local anesthesia direct tracheoscopy was performed and a reddish bleeding tumor mass was seen on the left wall of the trachea just below the vocal cord. This mass was removed with a cup forceps and the base was cauterized with the electrocautery. There was no bleeding following cautery. One week later, with the exception of some whitish exudate, no pathology was seen. There had been no further bleeding. The specimen was reported by the pathologist as tracheal adenoma. In view of the question whether a tracheobronchial adenoma is or is not a malignant tumor, the patient and the slide were examined by Dr. Rudolph Kramer of Mt. Sinai Hospital, New York, who found no recurrence. The specimen was studied also by Dr. Sadao Otani of the Mt. Sinai Hospital Pathological Laboratory, who reported that the "tumor structure definitely is that of carotid body tumor, probably originated in misplaced carotid body in the wall of the trachea."

There has been no recurrence after three years.

SUMMARY

A case is presented of a bleeding tumor mass in the left upper portion of the trachea, just below the vocal cords, which was reported as carotid body tumor, and has not recurred after three years. It is felt that it originated from misplaced carotid body tissue in the wall of the trachea. The history of the patient's father having had an epidermoid cyst of the esophageal introitus and the maternal uncle having had repeated bouts of hemoptysis for many years is of additional interest.

1010 BROWN BUILDING

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LXXXI

FURTHER STUDIES UPON THE SUBMUCOSAL COMPARTMENTS AND LYMPHATICS OF THE LARYNX BY THE INJECTION OF DYES AND RADIOISOTOPES

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Many years ago Hajek[1,2] demonstrated by a study of laryngeal edemas that submucosal compartments exist within the larynx, the edema tending to remain localized within the confines of these individual compartments.

The preliminary experiments to be described have, in an earlier communication, been reported upon by one of us.[8] These completely corroborated Hajek's observations. Additional studies have now been carried out and add further facts to those previously established. One can conclude that beneath the mucosa which lines the larynx a framework exists patterned in such a manner as to form anatomical compartments isolated from one another. Fluids injected, even under pressure, will not pass from one such compartment to the next. One of these compartments in the free margin of the true vocal cords has been described by Reinke and is known as Reinke's pouch.[4]

Although the observations to be reported upon may prove of clinical importance from the standpoint of a variety of diseases, the present purpose is to describe the findings solely as part of a basic anatomical study, and to determine the direction and extent of flow, and the fate of liquids injected submucosally into the larynx as a preliminary to

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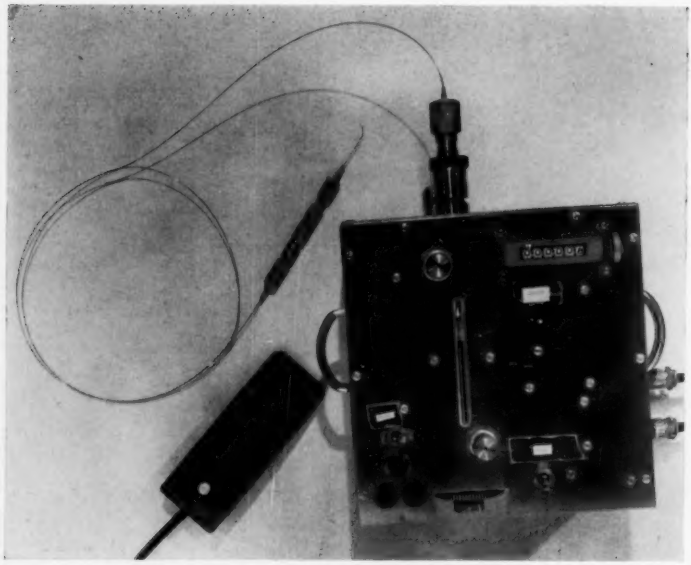

Fig. 1.—Electro-mechanical hydraulic pump-type radioisotope injector designed by Gamble and Libby.

establishing a technique for the possible future clinical use of radioisotopes in solution.

All liquid injections were performed with 4 per cent Direct Sky Blue which not only is capable of spread through the submucosal areas, but is taken up by the lymphatics as well.[7]

Injections were made into human living and cadaver larynges, and the living dog and the pig. Observations were recorded photographically. When appropriate, an ordinary hand syringe was utilized but controls were established by the use of a specially constructed mechanical injector designed to deliver an accurately measured amount of fluid under fixed pressure (designed by Dean P. Gamble and Raymond L. Libby, U.C.L.A. Medical Center) (Fig. 1).

The first experiment was performed in the living human larynx. Injections of dye were made into the true and false cords through a laryngoscope as an independent procedure prior to performing laryn-

gectomy for cancer of the epiglottis. The remainder of the larynx was not involved. The exact amount of injected fluid in this first experiment is unknown but the order of magnitude represented several tenths of a cc. The anterior commissure was intact since no incisions had been made into it, and the normal flow of fluid was not considered to have been interfered with in any way by the pathology which was sharply localized above the laryngeal inlet. After two hours the laryngectomy was begun, and was completed four hours post-injection.

A sharp demarcation of the hemilarynx was evident. The dye had spread over only one lateral half of the larynx, while the opposite side contained no dye (Fig. 2). There was no observable spread across the midline either by direct extension or through the lymphatics. The dye having spread upward from the interior of the larynx, continued over the arytenoid cartilages and aryepiglottic fold to their posterior external surfaces and into the region of the pyriform sinus only on the side of the injection. None was found on the opposite side even on posterior aspect. The findings were repeated and verified in two additional similar experiments in the living human. It is, therefore, considered to have been demonstrated (Figs. 2a and b) that within the limits of the experiment, the human larynx is compartmented into sharply demarcated right and left halves, including the lymphatics, and this observation has been found to hold true for all observed larynges including human subjects, both living and cadaveric, and for dogs and pigs.

Further, more detailed studies were carried out on human cadaver larynges of which 72 were used for the purposes of this study. While these first experiments in the living demonstrated the pattern of flow via lymphatic channels, the use of cadaver larynges and the injection of larger quantities of dye, outlined the compartment independently of the effect of lymphatic drainage. These injections were made at various sites as experience indicated necessary.

SUPRAGLOTTIC INJECTIONS

The first of the cadaver injections was made into the soft tissues of the lateral area of the epiglottis (Fig. 3). The dye spread as far as the lateral border of the cartilage, outlining the contour of the edge but not extending beyond it and reached downward to the level of the false vocal cord where its further spread was sharply terminated. The first of the recognizable submucosal compartments therefore extends from the lateral aspects of the supraglottic area above, to the level of the false vocal cord below, terminating medially at the border

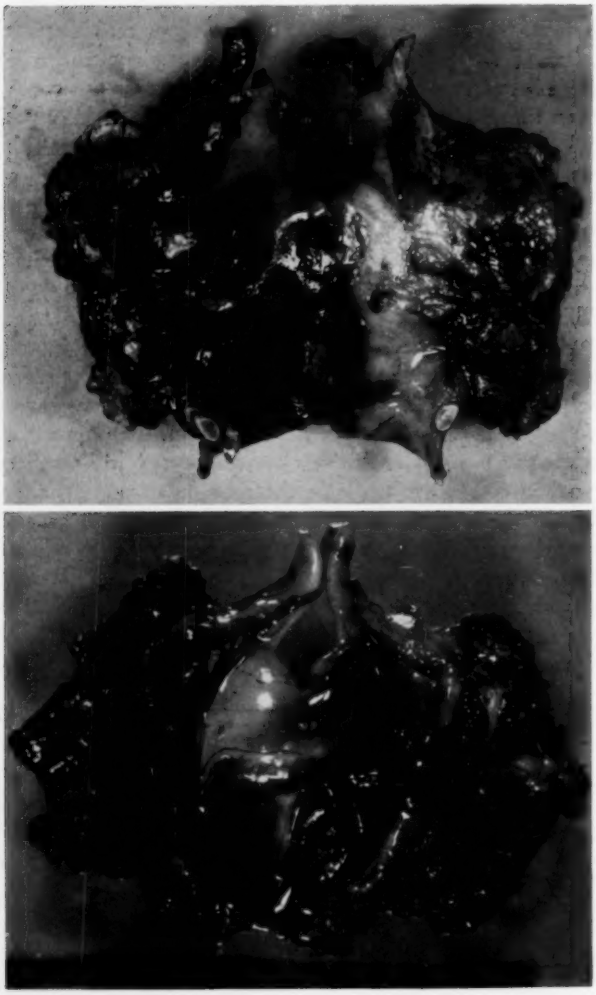

Fig. 2a.—Interior of larynx split through anterior commissure. 0.2 cc dye injected into right side below true cord five hours prior to laryngectomy. Demonstrating failure of dye to cross the midline. At time of injection the stained area was about one cm in diameter.

Fig. 2b.—Same posterior view. Note staining of posterior face of right arytenoid and aryepiglottic fold with failure of cross-over to opposite side.

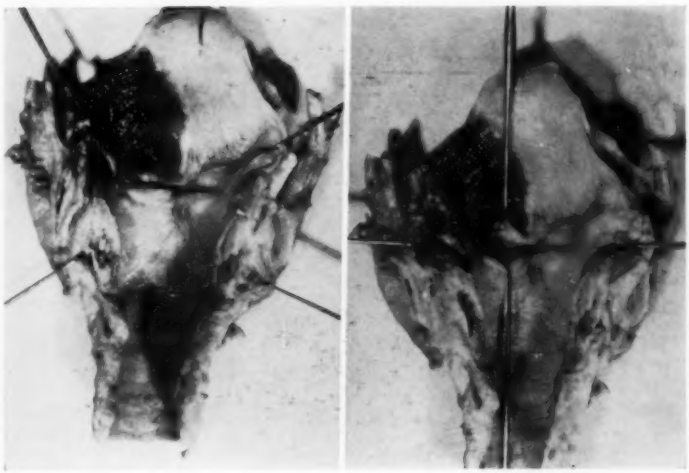

Fig. 3.—Massive supraglottic injection of dye at side 1 cm above middle third of false vocal cord. Cadaver larynx. Demonstrating localization to injected lateral half above level of true cord.

Fig. 4.—Supraglottic injection (same specimen as Figure 3). Note absence of dye on under surface of false vocal cord and in ventricle.

of the cartilage of the epiglottis, and below this level at the midline. It is important to note that when a massive injection is made supraglottically on one side the lower limit of the spread is at the free border of the false vocal cord with the dye failing to penetrate to the inferior surface of the false cord so that the ventricle is immune to the spread of fluids injected above it. The ventricle is, therefore, compartmentwise, and, as will be further demonstrated later, isolated from the false vocal cord above it (Fig. 4).

Supraglottic injections performed at the midline result in a spread to both sides involving the entire epiglottis. Despite an extension downward to the level of the false cord, no filling of the ventricle took place even when large amounts of dye were used (Fig. 5).

INFRAGLOTTIC INJECTIONS

When dye was injected submucosally just below the level of the true vocal cord, a sharp level of demarcation occurred at the midline. This extended from the level of the true cord to the lower limit of

Fig. 5.—Midline injection at site of needle.

the cricoid cartilage where a sharply defined limit was particularly to be noted (Fig. 6). Therefore, it is established that not only above but also below the true cord each lateral half of the larynx represents an isolated area in relationship to the opposite side. It is further to be noted that spread below the level of the cricoid cartilage does not take place, which indicates the isolation of the larynx from the trachea below it. This observation might prove to be of great practical importance.

GLOTTIC INJECTIONS

As in the supraglottic injections the ventricle remained free of dye when the infraglottic area was injected. This region, corresponding to the site of the saccule, is therefore an independent, isolated entity, which can be further proven by direct injection of the saccule itself. In certain specimens the saccule is particularly prominent, filling the cavity of the ventricle and injections can be made directly into it without difficulty. When directly injected, the saccule bulged outward filling the ventricle (Figs. 7 and 7b). No dye passed upward into the substance of the false cord or downward into the true cord. It is interesting to note that even though the ventricle in the living communicates freely with the interior of the larynx, the valvular action of the aditus is such that no dye was extruded into the lumen

Fig. 6.—Infraglottic injection. Demonstrating limit of spread at midline medially and at lower border of true vocal cord superiorly.

of the larynx. This action evidently represents a physiological mechanism that is not thoroughly understood but is no doubt anatomically related to the mechanism which permits a laryngocele to remain distended with air. The ventricle on one side having been injected, a trifling amount of dye in contrast to previous observations, traversed the midline via a single lymphatic with a suggestion of its entrance into the opposite ventricle. This transmission through the lymphatics as was further demonstrated in experiments on the pig which will be described later.

Beginning on the free edge of the vocal cord and extending over the top of it into the region of the ventricle there is, apart from the saccule and not to be mistaken for it, the free space of the so-called laryngeal bursa which can readily be entered with a needle. It extends for the entire length of the true vocal cord, corresponding to its medial free border (Fig. 8). The structure has been described and injected by Ottaviani, and anatomically seems to correspond to the pouch of Reinke. When injected the limits of spread of the dye are sharply demarcated above and below with no passage across the midline, so that the limits of the distended space are well defined. The bursa can be filled to the point of rupture (Fig. 9), without dye entering the saccule immediately adjacent to it or crossing over the anterior commissure. In contrast, therefore, to injections within the saccule which seem to have possible access to the opposite side, the submucosal bursal

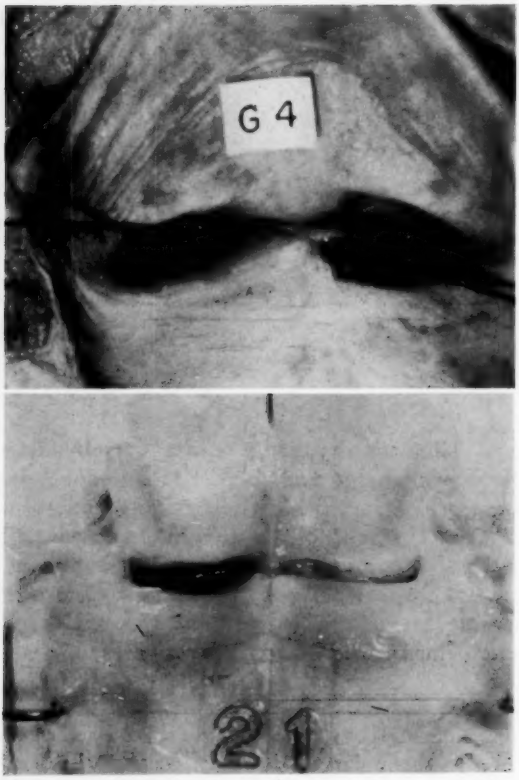

Fig. 7a.—Injection of saccule of human ventricle (left). With the saccule bulging from injected dye no spread beyond it is visible. On the right side the vocal cord itself has been injected and the saccule above it is seen free of dye. Needles mark site of injection.

Fig. 7b.—Demonstrating isolation of injected saccule of dog. Note the single lymphatic channel extending from the saccule across the midline to the opposite saccule.

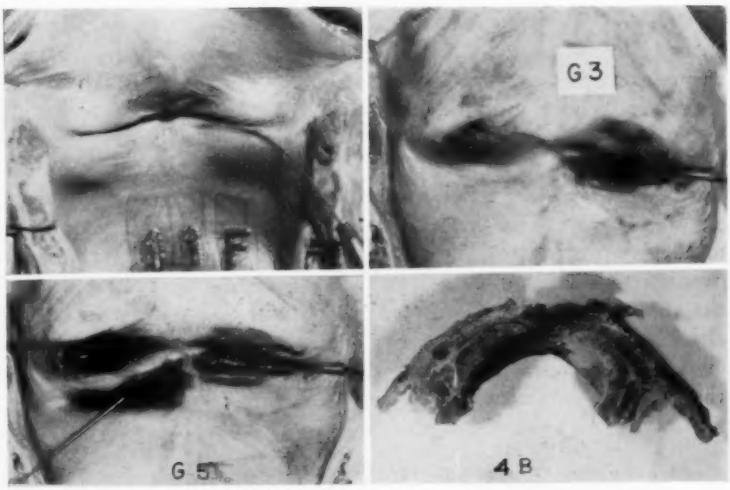

Fig. 8.—Semiflexible needle in true vocal cord bursa.

Fig. 9.—The laryngeal bursa on the margin and upper surface of the true vocal cord.

Fig. 10.—Right side: True cord bursa injected. Left side: Dye injected below bursa and in saccule above it. Demonstrating isolation of true cord bursa from injections above and below.

Fig. 11.—Cross section of larynx (dog) immediately below the cricoarytenoid joint. Demonstrating failure of cross-over of dye to opposite side after injection of middle third of true cord. Animal permitted to survive for five days following injection.

sac in the free margin of the true vocal cord is completely isolated from the opposite side and no such passage of injected fluids takes place.

By utilizing the opposite side of the same larynx and placing one injection in the true cord below this bursa, and a second injection immediately above it in the saccule (Fig. 10), the bursa can be effectively demonstrated in a negative way as a well delineated compartment entirely free of dye which had been generously injected both above and below it. Further examples of the isolation of this bursa from all surrounding structures will be demonstrated in experiments on living dogs.

The above experiments, having been performed on cadavers, demonstrate the limits or boundaries of the submucosal compartments.

Further studies incorporating the effect of the lymphatics need to be taken into account. This can be satisfactorily demonstrated only in living subjects. Upon the living, the first of such experiments, apart from the initial experience with the laryngectomized patients, was performed upon the dog. The larynx was split through the anterior commissure and a small drop of dye injected submucosally just below the level of the true vocal cord at its middle third. After one hour the margin of the vocal cord representing the site of the bursa was still free of dye, which had passed deep to the bursa and entered the superior levels of the larynx. It did not at any point cross the midline via the route of the posterior commissure. Any possible cross-over anteriorly had, of course, been eliminated by the incision through the anterior commissure. After 12 days the dog was sacrificed and, although, for the most part, the dye had disappeared, there was no evidence at all of its having crossed the midline. On its posterior aspect the dye had left the confines of the larynx and infiltrated the pyriform sinuses and the hypopharynx but only on the same side as the injection.

To overcome the limitations imposed by having destroyed the continuity of the anterior commissure, further studies were made with the anterior commissure intact. Access to the interior of the larynx was obtained by severing the trachea transversely between the third and fourth tracheal rings, and supporting the superior severed margin with hooks. The interior of the larynx was thereby exposed to view and injected from below. Injections of a drop of dye were then made at a point just below the true vocal cord, at its middle third over a site corresponding to that of the previous experiment. The larynx was permitted to remain intact for four hours. The dye after this period again by-passed the free margin of the vocal cord without filling the bursa and passed upward behind it to the superior levels of the larynx, gaining access to the hypopharyngeal space by being carried over the aryepiglottic fold. It furthermore did not pass across the midline to the opposite side, thereby demonstrating that the anatomical isolation of one half of the larynx from the other is demonstrable, even with the anterior commissure intact.

This experiment was repeated upon a pig, using the tracheal incision and again without destroying the anterior commissure. Dye was injected from below at a site just inferior to the middle third of the true vocal cord. The spread in the pig was especially interesting and particularly well demonstrated. The dye for the most part reached only to the midline obviously not crossing it subglottically or supraglotticaly, by either the anterior or posterior commissure, but a very strange cross-over in a thin sharply demarcated linear stripe along

Fig. 12.—Radioisotope scanner (Scintiscanner) custom built for use on experimental animals.

the margin of the vocal cord took place. Its significance has not yet been fully interpreted and although consistently seen in the pig, the finding has not been observed in either the dog or in humans.

Observations of cross sections made after the injection of dye in the living dog corroborate the findings already outlined. Dyes injected submucosally from below with the anterior commissure intact are seen in cross-section not to cross the midline even after many days. When injected it spreads widely on the one side, staining the muscle mass of the intrinsic musculature, and penetrating deeply enough into the structure of the larynx to stain the internal perichondrium without infiltrating between it and the thyroid cartilage, so that the latter structure remains unstained (Fig. 11). Although there is at the lower border of the cricoid cartilage a sharp line of demarcation beyond

which the dye does not pass by direct extension, it is, nevertheless, picked up by the lymphatics accompanying the inferior laryngeal vessels and recurrent nerve and carried through the cricothyroid membrane into the tissues of the neck via the usual channels of lymphatic flow.

The compartmental isolation of the larynx from the trachea, as demonstrated by the invariable failure of dye injected into the larynx to spread beyond the inferior level of the cricoid cartilage, is of particular interest, not only anatomically but from many practical standpoints including the possibility of injected liquids of therapeutic value such as the radioisotopes remaining within the confines of the larynx.

It is to be noted that the predominant direction of flow of fluids injected into the larynx and transported by the lymphatics is upward with an eventual spreading out over the laryngeal mucosa to reach the aryepiglottic folds, then flowing over them into the posterior aspect of the larynx and the hypopharynx. The lymphatics of the larynx, therefore, seem to drain for the most part into the superior laryngeal trunks.

A limited number of injections of dye were made into the mucosa of the membranous trachea posteriorly immediately below the cricoid cartilage. Observations were made at five and at twelve hours. The spread of the dye via the lymphatics was noted to be entirely downwards into the further depths of the trachea. None of the dye passed upward into the larynx either by submucosal direct extension or via the lymphatics. Except for a narrow "twilight zone," there was no spread across the midline. Dye injected a few millimeters above this level just above the lower border of the cricoid cartilage and within the confines of the larynx, did, to the contrary, spread upward. There is, therefore, a vast difference in the distribution of dye when it is injected just below the level of the cricoid cartilage and just above it. This factor may be of great clinical importance and should be given further study.

While Direct Sky Blue is admirably suited to relatively short-time observations it is not satisfactorily identifiable after 10 or 12 days following injection. For longer term periods of observation other techniques were sought. It had, in a series of experiments designed for another purpose, been determined that by "scanning" the larynx with a specially constructed scanner for use on laboratory animals, the presence of a radioactive isotope (chromic phosphate) could be identified with ease after as long as eight weeks, representing the radioactive

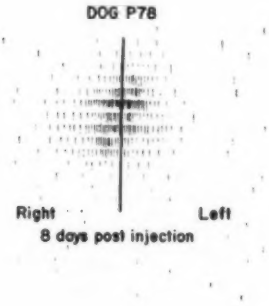

Fig. 13.—Scintigram of dog's larynx 8 days following bilateral injection of radioactive isotope generally distributed throughout the larynx. Heavy vertical superimposed black line is midline of larynx.

half-life of the substance (Fig. 12). Controls were used by injecting both sides of a dog's larynx and carrying out uptake studies. At the suggestion of Mr. Max Fields, one lateral half of the dog's larynx was injected with this material using the mechanical injector previously mentioned (Fig. 13). Ten injections were made, each representing 0.07 cc and 37 microcurie of radioactive chromium. The distribution was over a wide area of the right side of the larynx from the lower border of the cricoid cartilage to and including the epiglottis. Injections were made after splitting the anterior commissure as for laryngofissure. After varying periods up to four weeks the dog was tested prior to sacrifice by scanning the larynx through the soft tissues of the neck and by direct scan following removal of the larynx (Figs. 14a, b and c). No cross-over of radioactive substance beyond the midline could be detected after this period. This was likewise true in subsequent experiments when the anterior commissure was not split. The injected side remained radioactive and responded quantitatively to the degree expected by estimates of the anticipated decay of the isotope (Figs. 15a and b).

SUMMARY

Injections of dyes in solution were made into various areas of the interior of the larynx and the direction and extent of spread within the larynx noted. Seven areas on each side, more or less separated one from the other, insofar as the passage of injected fluids is concerned, were identified. Failure of fluids to pass by way of the lymphatics from one side of the larynx to the other was established for a period of

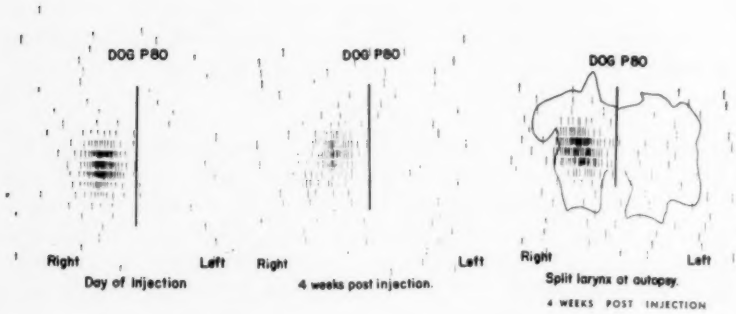

Fig. 14a.—Scintigram taken through intact neck immediately following injection of radio-active isotope generally distributed throughout right side. Anterior commissure split. Superimposed heavy solid vertical line represents midline of larynx.

Fig. 14b.—Same as 14a, 4 weeks post-injection immediately prior to sacrifice.

Fig. 14c.—Same as 14a, 4 weeks post-injection. The outline of the larynx following its removal at autopsy is superimposed.

as long as four hours in living humans, for 12 days in the instance of solution of dye injected into living dogs, and for 8 weeks in the instance of radioactive isotopes in solution injected into dogs.

Appropriate limits of "extrinsic" and "intrinsic" laryngeal division were suggested, upon the basis of anatomical compartmentation.

It was likewise suggested as a preliminary unconfirmed observation that the spread of carcinoma of the larynx, in general, tends to conform to the compartmentation of the larynx as described.

A pattern for the injection of radioisotopes for possible future clinical use was established.

CONCLUSIONS

Experiments were conducted to observe the spread by direct extension and via the lymphatics of dyes in solution following their injection, at various sites, into the human cadaver larynx, the living human larynx, the living dog and pig larynges. Further preliminary investigations with radioactive substances was similarly conducted in living dogs. Certain conclusions appeared justified as follows:

Fig. 15.—Larynx injected from below through incision in trachea. Anterior commissure intact. Scintigram five weeks post-injection of radioactive isotope injected throughout the left side. Outline of larynx superimposed. Note failure of cross-over to opposite side despite intact anterior commissure.

The interior of the larynx is anatomically divided into a number of submucosal compartments which as far as fluids injected under pressure are concerned, are anatomically isolated from each other. Hajek demonstrated that this clinically conforms to the pattern of laryngeal edemas. The experiments reported herein indicate this compartmentation conforms to the following anatomical pattern:

A) The larynx is divided into right and left halves from the lower level of the cricoid cartilage to, and including, the aryepiglottic folds and epiglottis. This applies in man, the dog and the pig.

B) Considering each side independently, specific compartments are recognized to exist as follows:

1. From below the level of the true vocal cord at its medial margin to the lowermost limits of the larynx.

2. The medial border and part of the superior surfaces of the vocal cord itself corresponding to the description of Reinke's pouch or the vocal cord bursa demonstrated more recently by Ottaviani, or both.

3. The laryngeal saccule.

4. The region of the ventricle, including the superior face of the true vocal cord, the ventricle itself and the inferior surface of the

false vocal cord. (The exact relationship between the ventricle and the saccule has not been determined. These latter areas corresponding to the ventricles and the adjacent structures when considered together, remain isolated as a unit when massive injections of dye are made submucosally into the human cadaver larynx either above or below this area. This suggests that a logical division into "intrinsic" and "extrinsic" divisions could be made on an anatomical basis and that the intrinsic larynx be considered the medial margin of the true vocal cord, its superior surface, the ventricle itself and the under-surface of the false vocal cord, and the remainder of the larynx be considered "extrinsic.")

5. The lateral wall of the larynx beginning at the free border of the false vocal cord and extending upward to the aryepiglottic folds and including the latter.

6. The lateral margins of the epiglottis beyond the limits of its cartilaginous portion.

7. The area outlined by the limits of the cartilaginous epiglottis.

It is pointed out that smaller subcompartments probably exist which in all likelihood include the synovial capsule of the cricoarytenoid and cricothyroid articulations and the site of the cartilages of Wrisberg and Santorini, as well as an isolated compartment for the arytenoid cartilage itself.

The injection of minute quantities of the dye into the submucosal spaces of the various compartments in the living (human, dog, pig) demonstrate the flow and spread of dye by way of the lymphatics rather than by pressure. The studies have not been completed. The division of the larynx into isolated right and left halves was demonstrated as existing not only on the basis of submucosal compartments but also corresponding to the pattern of the distribution of lymphatic channels. This has been amply demonstrated in both the dog and the human. A possible exception exists resulting from injections into the region of the true vocal cord, as was demonstrated only on the pig, the cross-over being limited to the delineation of a sharply defined thin segment along the free margin of the true vocal cord. It is felt that this cannot be completely evaluated from the studies at hand.

It was further observed and demonstrated that the spread of injected liquids by the intralaryngeal lymphatic route is for the most part upward even when the injections are made at the lower levels.

The larynx itself is found to be essentially independent of the trachea, both from the standpoint of submucosal compartmentation, and lymphatic channel distribution. Thus dyes injected into the membranous trachea just below the level of the inferior border of the cricoid cartilage pass downward along the trachea and never upward into the larynx.

When the above observations were first presented at the 1956 meeting of the American Laryngological Association it was stated, but only with extreme reservations, that there might be a relationship between the localization and direction of spread of intralaryngeal cancer upon the anatomical basis of facts herein presented. Additional evidence, which, however, requires more study, seems at this time to lend further support to these impressions. As one observes the distribution of cancer of the larynx in an increasingly larger number of specimens the more likely does it seem that in many instances the tendency is for localization and spread to take place in a pattern corresponding to these tissue spaces. Many exceptions will, of course, be found but in many more instances a definite correlation appears to exist. The practical clinical value of this is not to be overlooked so that for example in this era of an increasing tendency towards fractional laryngectomy, one would on these grounds alone hesitate to perform transverse partial laryngectomy whereas vertical hemilaryngectomy has the advantage of coinciding with specifically isolated laryngeal segments.

It has, as the principal purpose of these experiments, been established that injections of fluids made for therapeutic purposes such as the possible future use of radio-isotopes in the treatment of cancer of the larynx, needs to be made by multiple injection in accordance with the division of the larynx into its various compartments as described.

The observations of Hajek pertaining to the anatomical basis for an explanation of edema of larynx occurring over specifically localized areas is confirmed.

The study of the spread of solutions within the larynx has partially been made by injections through the laryngofissure approach. This obviously distorts the results from the anatomical standpoint but is considered important from the practical point of view in that injections of radio-isotopes may more effectively be made by this route than any other. This objection can be overcome by the more

difficult and uncertain approach into the intact larynx through a transverse tracheal incision or through the suspension laryngoscope. The possibilities of the latter have not been explored.

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LXXXII

MYOLOGY OF THE PHARYNX OF CAT, DOG, AND MONKEY WITH INTERPRETATION OF THE MECHANISM OF SWALLOWING

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SALT LAKE CITY, UTAH

There has been much careful anatomical study of the development and interspecies variation of the pharynx and the related structures of the mouth and larynx.[1-6] The general principles of variation and adaptation of the pharynx in the variety of species have been comprehensively and perceptively reviewed by Negus,[4,5] with astute inferences regarding the basic motions of cephalad protrusion and caudad constriction involved in the motor performance of swallow. The process of swallow has been observed roentgenographically in the dog by Meltzer[7] and in fowl by Barclay.[8] The interspecies variety of functions of the tongue has been described by McGregor[9] and by Kelemen.[10]

The distinctive opportunity utilized in the studies here reported is that of correlation of comparative myologic studies of the pharynx with multiple channel electromyographic observations of the consistently co-ordinated performance of swallowing[11] in the cat, dog, and monkey. This correlation has contributed additional understanding of the motor performance of swallowing.

METHOD

Detailed dissections of the intrinsic and supporting musculature were performed in pharynx area of 10 cats, 11 dogs, and 7 cynomolgus monkeys formalinized following multiple channel electromyographic studies of reflexly elicited performance in this area.[11] The paired wire intramuscular electrodes were commonly left in place and their estimated locations confirmed in immediate post mortem dissections.

From the Department of Pediatrics, University of Utah College of Medicine, Salt Lake City, Utah. Aided by a grant from the National Foundation for Infantile Paralysis, and from the United Cerebral Palsy Research and Educational Foundation.

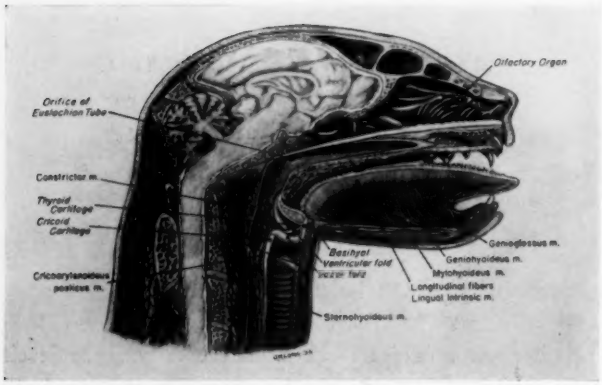

Fig. 1.—Sagittal view of head and neck of cat. Septum of nose excised to show olfactory organ.

Points of variations as the result of action pose and individual variations were compared with additional specimens obtained for the purpose of this anatomical study. The majority of specimens were dissected following sagittal or slightly parasagittal division; a few were dissected by frontal approach. Critical minute details were observed under magnification. Only mature animals were used in this study.

The illustrations of the cat (Figs. 1-3), dog (Figs. 4-6), and monkey (Figs. 7-9) are of typical gross alignment of neck, mouth, and pharynx, and relative proportion of the individual muscles. These illustrations differ somewhat from those of others in that the tongue, hyoid, and larynx are displaced slightly ventrally and caudally, in compensation for their apparent agonal and post mortem displacement. The pharynx is thus shown as an open passage.

ANATOMICAL OBSERVATIONS

The basic arrangement of the pharynx area of these three species is similar, with a relatively spacious pharynx, joined by a broad but variably restricted faucial isthmus to a large mouth. The tongue in each is prominent and its posterior portion comprises a part of the anterior wall of the pharynx. Each has a muscle-encircled palato-pharyngeal orifice at the cephalic end of the pharynx and a complex arrangement of articulated cartilages of the larynx, providing multiple

Fig. 2.—Dissection of cat from sagittal plane, showing intrinsic muscles of pharynx, tongue, and larynx.

valvular control of respiration. The craniovertebral angle is obtuse in each species, though to a lesser degree in the monkey. In each, the pharynx is similarly enclosed between the cervical vertebrae and the mandible and posterior skeleton of the face, with the hyoid at or slightly above the transverse level of the posterior-inferior portion of the mandible. The anterosuperior portion of the thyroid cartilage is in juxtaposition to the hyoid at the midline and the tip of the epiglottis approximates the palate at the midline or protrudes minimally into the palatopharyngeal orifice.

The Hyoid Skeleton. The most significant interspecies variations are those of the anatomical arrangement of the hyobranchial apparatus and its suspensory musculature. The hyoid skeleton is highly similar in these three species, with the exception of an incidental bulbous expansion of the median body or basihyal in this species of monkey to form a rigid prelaryngeal air sac. In each species an arch-shaped strut extends posteriorward from the basihyal to articulate with a superior protrusion at the posterolateral angle of the thyroid cartilage. The thyroid cartilage and the combined basihyal and thyrohyal are moved in relation to each other at this hinge by action of the prominent laterally placed thyrohyoideus. In dog and cat, a system of three articulated cartilages extends in arch-like contour from the

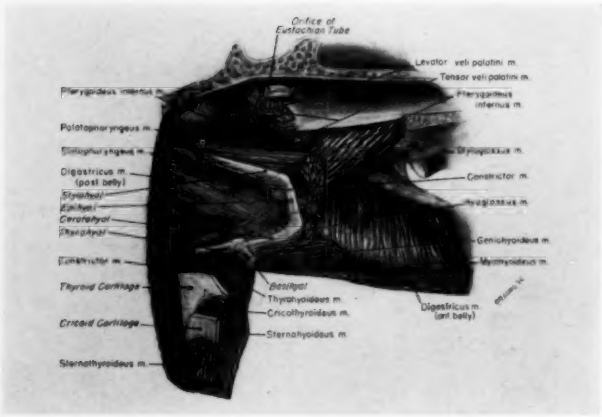

Fig. 3.—Further dissection of cat, showing supporting musculature of the tongue, hyoid, larynx, and pharynx.

basihyal to the base of the cranium. The lowest of these, the ceratohyal, is joined firmly to the basihyal. The uppermost segment is the familiar styloid process or stylohyal, and the intermediate segment is termed the epihyal. In the monkey, the intermediate segment consists of a dense fibrous band—the stylohyoid ligament. The lateral limbs of the hyoid skeleton are variably joined by thin planes of muscle. In the dog and monkey, this muscle, to which we have given the term "hyoideus," joins the ceratohyal to the posterior tip of the thyrohyal close to its articulation with the thyroid cartilage. In the cat, the hyoideus joins the length of the ceratohyal and epihyal to the length of the thyrohyal. The stylohyal and epihyal, or the stylohyoid ligament, are enclosed within the styloid muscles.

The Styloid Muscles. The largest of these styloid muscles in each species is the styloglossus, which is relatively much larger in dog and cat. The styloglossus is joined by the hyoglossus originating on the basihyal and ceratohyal in all three species, to enter the lateral portion of the tongue. In the cat and monkey, a separate stylopharyngeus was identified as a small slender muscle. No homologue of the stylolaryngeus of the human was found in these species.

The Digastricus Muscles. The anterior digastricus in each of these species is prominent and large-bellied (these are not included in the

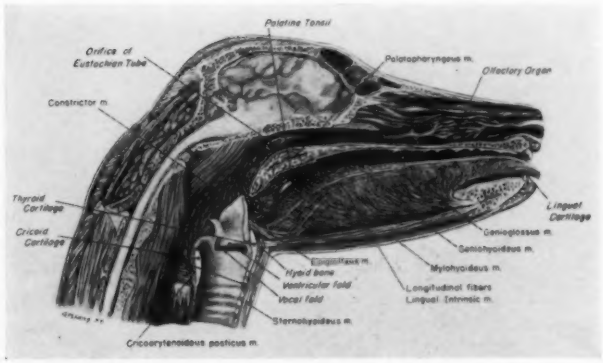

Fig. 4.—Sagittal view of head and neck of dog. Septum of nose excised to show olfactory organ.

accompanying illustrations). In the dog and cat, the posterior bellies are also very prominent. In the monkey, the anterior belly inserts into a dense, fibrous semicircle, which is continued posteriorly and superiorly as a slender digastric ligament continues to the digastric fossa of the cranium as a small tapered, round muscle.

Submental Suspension of the Hyoid. The geniohyoideus and mylohyoideus are consistent in their relative prominence and arrangement within these species. The geniohyoideus is in each case a prominent cylindrical paired muscle inserting into the basihyol. The mylohyoideus is an homogeneous, thin plane of muscle whose fibers are oriented transversally and insert into a median raphe.

The Pretracheal Muscles—Sternohyoideus, Sternothyroideus, Thyrohyoideus. These also are highly similar within these species. Each is a large, broad, and somewhat flattened muscle. Below the larynx, the sternohyoideus and sternothyroideus fuse progressively. The thyrohyoideus is large and in striking disproportion to the hyoideus, cricothyroideus, and the other intrinsic laryngeal muscles.

The Constrictor Musculature. The constrictor muscles in the lateral and posterior walls of the pharynx are highly similar, consisting typically of flat planes of fibers which are closely parallel or slightly oblique and overlapping. In none of these species does the superior constrictor extend above the level of the hard palate. Inconstantly in

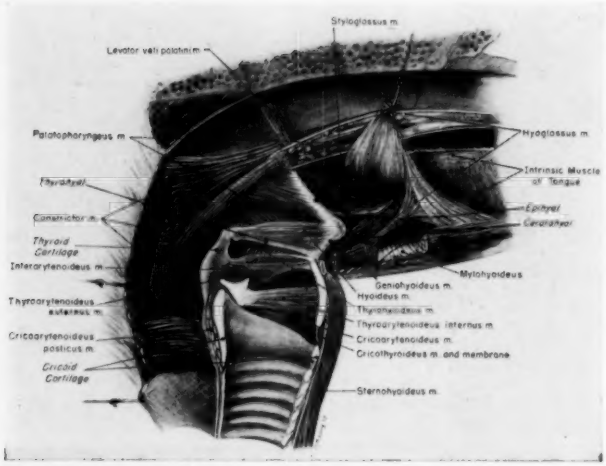

Fig. 5.—Dissection of dog from sagittal plane, showing intrinsic muscles of pharynx, tongue, and larynx. Hyoglossus is separated at origin and reflected to demonstrate musculature of tongue.

the dog and monkey, there is a slight increase in diameter of these fibers at their lower (caudal) margin, depending upon agonal motor activation. In the cat, however, there is no thickening noted in this area, a variation which is probably related to a cufflike mucosal fold at this area which is observed to be consistently down-pointed and, perhaps, has a valvular action. There is considerable interspecies variation in the anterior origin of these muscles and they originate typically from the following structures, considered in cephalocaudad sequence:

The skeleton of the face. At the lateral edge of the palate and, in the dog, from the skeleton at the anterior edge of the palate.

From the epihyal, ceratohyal, and thyrohyal, in dog and cat, and from the cerato- and thyrohyal, in monkey.

From the lateral aspect of the thyroid cartilage and the inferior-lateral margin of the cricoid cartilage and, in the cat, from a raphe joining a portion of the inferior constrictor directly to a portion of the thyrohyoideus. In the cat, a portion of the inferior constrictor arises from the site of common insertion of the cricothyroideus and sternothyroideus upon the thyroid cartilage.

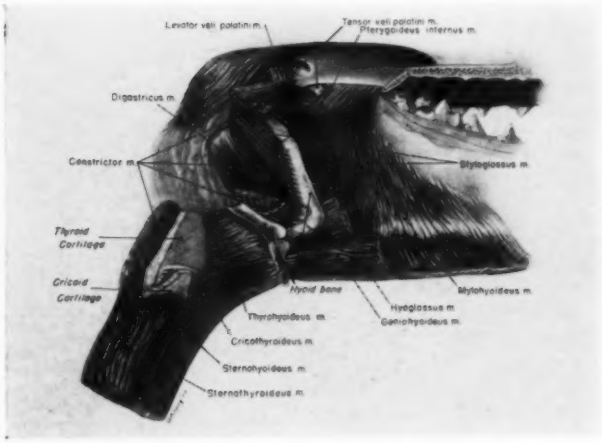

Fig. 6.—Further dissection of dog, showing supporting musculature of the tongue, hyoid, larynx, and pharynx. Fragments of thyroid and cricoid cartilages remain *in situ*.

It was not possible to distinguish "superior," "middle," and "inferior" pharyngeal constrictor upon the basis of any criteria of origin among these three species. In the cat, a small portion of the constrictor extends forward with the styloglossus into the tongue.

The Palatal Musculature. There is considerable variation among these species in the arrangement of the palatopharyngeus muscle and the relative prominence of the levator veli palatini. In the cat, the palatopharyngeus and superior constrictor are combined as a prominent muscle mass, an undivided portion of which arises from the lateral portion of the hard palate and proceeds within the lateral edge of the palate to fuse with the combined mass of palatopharyngeus and superior constrictor. An otherwise undistinguished portion of the combined mass extends inferiorward in a smooth fan arrangement, fibers of which reach nearly to the lower border of the constrictor sleeve. There is a prominent, broad levator muscle which interdigitates at the lateral border of the palate with the palatopharyngeus but does not have fibers extending far medialward into the palate.

In the dog, there is a distinguishably separate origin of the palatopharyngeus in a more medialward area of the posterior margin of the hard palate. These fibers course in the palatopharyngeal folds

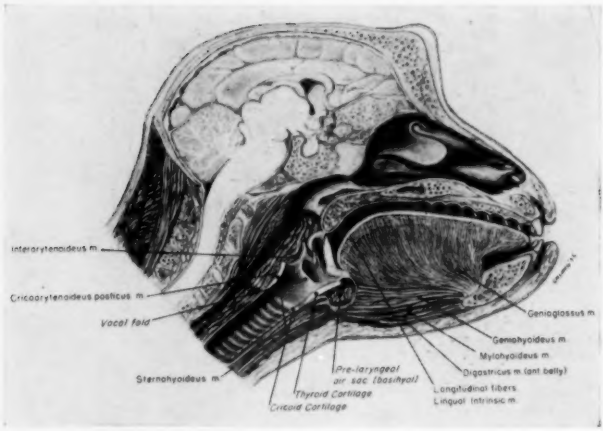

Fig. 7.—Sagittal view of head and neck of monkey.

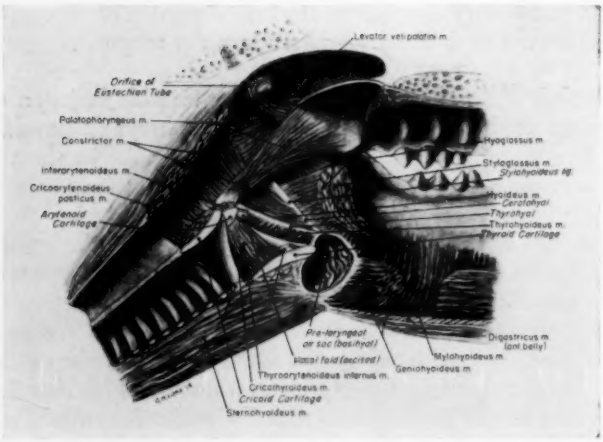

Fig. 8.—Dissection of monkey from sagittal plane, showing intrinsic muscles of pharynx, tongue, and larynx.

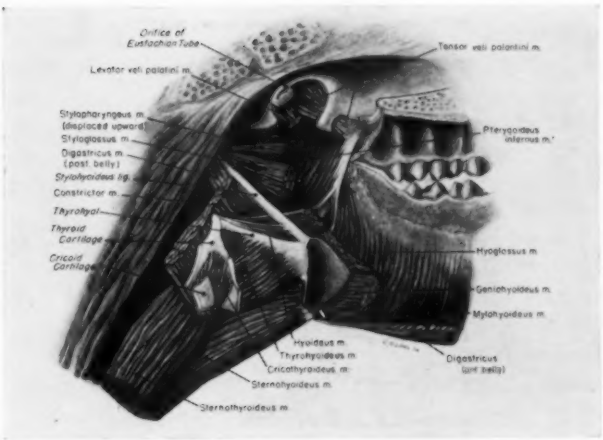

Fig. 9.—Further dissection of monkey, showing supporting musculature of the tongue, hyoid, larynx, and pharynx.

adjacent to but not consistently fused with the upper portion of the constrictor arising from the pterygoid process, and extend into the lateral portion of the constrictor musculature to interdigitate at various levels. Its fibers generally do not extend as far caudally as those of the cat.

In the monkey, the palatopharyngeus is more prominent and distinguishable. It originates as a broad fan from the pterygoid at the side of the soft palate, and descends as a separate band to the lateral pharyngeal wall where some of its fibers interdigitate over an extensive vertical range. A discrete bundle inserts into the area af articulation of the thyrohyal with the posterosuperior tip of the thyroid cartilage. The levator is also prominent but, as in the cat, its fibers do not extend far medialward into the palate. The body of the palate proper is singularly free of musculature. The levator interdigitates at the firm palatal aponeurosis with the palatopharyngeus but without fibers extending far medialward to the body of the palate. Correspondingly, the general anatomical arrangement of the palate in monkey is distinctive in that it is relatively short and is joined throughout its length to the posterosuperior pharyngeal wall by a flexible median raphe. Thus, the palate can be displaced upward but not downward from its apparent rest position. The palatopharyngeal folds are more narrow than those of the cat or dog.

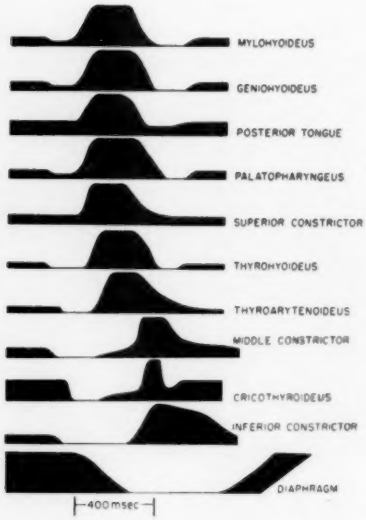

Fig. 10.—Schematic summary of electromyographic activity in deglutition of the unanesthetized dog. Height of line for each muscle indicates intensity of action observed, per cathode ray oscillograph.[11] (Reproduced through the courtesy of Charles C. Thomas Publishing Company)

COMMENT

By observation of interspecies variations, we are able to distinguish the essential elements of muscle arrangement within the pharynx area. Thus, in the face of anatomical variations of origin and of insertion of the palatopharyngeus muscle in the cat, dog, and monkey, it is still effective in accomplishing a characteristic combination of actions in swallowing, consisting of sphincteric closure of the palatopharyngeal isthmus and elevation of the pharynx walls.[4,5]

Analogously, there is considerable variation in arrangement of skeleton of the styloid group of supporting muscles, but these variations are consistent with the necessary mobility of the pharynx and associated structures in relation to the skeleton of the face, the basicranium, and the cervical vertebral column. Very appropriately, the hyoid skeleton of the monkey is distinctively interrupted by replacement of the epihyal with the stylohyoid ligament, as in the human. This difference is appropriate to greater mobility of the pharynx, which is necessary for consistent physical relation of the pharynx to the more mobile cervical area of the monkey. This also allows for greater

mobility of the pharynx and posterior mouth in this species in which there is more intra-oral manipulation of food.

The essential homologic variation in the muscles accomplishing elevation of pharynx is that of relative distribution of their insertion upon the tongue-hyoid-larynx column. Thus, the palatopharyngeus of the monkey has a consistent partial insertion upon the articulation of the thyrohyal with the posterior-superior protuberance of the thyroid cartilage, an arrangement in contrast with that in the cat and dog, in which this muscle is inserted exclusively into the lateral posterior pharyngeal wall. A comparable homologic variation is that of the relatively greater prominence of the styloglossus in the cat or dog, which may be interpreted as an adaptation to the forcible initiation of swallow of unchewed masses of meat in these species. It is apparent, however, that in the basic motions of swallowing the specialized structures of the anterior wall of the pharynx are elevated together.

The basic sequence of motions of the pharynx in swallowing have been well described by Negus[4,5] by inference from comprehensive homologic study of the anatomy of the pharyngeal area and swallowing motions. These consist of a cephalad engulfing action of the pharynx wall and a caudad constriction. Negus illustrates this sequence by description of prehension and swallowing by the snake, in which the whole cephalic area participates in the initial enclosing action.

Recently, the basic motions of swallowing as identified by Negus have been further validated by a multiple channel electromyographic study by Doty and Bosma[11] (Fig. 10). The "whole muscle" electromyogram of multiple separate muscles was simultaneously observed in anesthetized or medullary transsected dog, cat, and monkey, during elicitation of swallowing by stimulation of the superior laryngeal nerve or tactile stimulation of mucosa of the pharynx. The swallowing action was found to be strikingly similar in pattern in these three species and to remain unchanged in the face of variation in the depressant agents, or hypoxia, or simultaneous stimulation of the peripheral nerves. In all three species, swallowing was typically initiated by activation in the geniohyoideus and mylohyoideus, muscles moving the pharynx in the direction of the bolus, in the superior constrictor and palatopharyngeus, closing the palatopharyngeal isthmus, and in the posterior tongue. The activation then proceeded in a caudad sequence, in parallel in the constrictors in the pharynx and the analogous muscles of the hyoid-larynx column, preceded by a distinguishable instant of inhibition.

The motor action of swallowing which is the basic performance of the pharynx, is thus further indicated. The consistency of this coordination in the face of homologic anatomical variation is striking. It is to be expected that this performance will be likewise consistent in the circumstance of variety of development within the species.

SUMMARY

Dissection studies of the musculature of the pharynx area of cat, dog, and monkey are reported. The anatomical arrangements are compared, and the basic patterns of musculature distinguished. These patterns are related to earlier electromyographic studies of swallowing in these species.

UNIVERSITY OF UTAH

The anatomical illustrations are the work of Mr. Gene Long, to whom the author is much indebted.

The author gratefully acknowledges the assistance in preparation of this article given by Dr. George Kelemen, of the Department of Otology and Laryngology, University of Harvard Medical School, and of Dr. Robert W. Doty, of the Department of Physiology, University of Utah.

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LXXXIII

THE VARIABILITY OF THE LATERAL SEMICIRCULAR CANAL

THOMAS HORACE EVANS

NEW YORK, N. Y.

The author[1] has previously explained that the lateral semicircular canal is depressed about 10° caudolaterally when the cranium is narrow in type, but that the depression of plane may reach as much as 40° in patients having a wide cranium. When the superior canal is tilted obliquely[1] the lateral canal is correspondingly depressed. A clear view of the superior canal will show (in research dissections) whether the superior canal is exactly vertical or inclined obliquely.[2] The exactly vertical type is equated with the narrow cranium. The posterior canal varies[3] so that the entire labyrinth varies as a unit. It will be seen, therefore, that the oval window is affected by the tilting of the labyrinth,[2] and faces more rostrally in wide crania with its rostral end tipped upward.

The significance of this is extreme. The membranous canal within the bony one has its attachment longitudinally along the convexity of the system. With depression of approximately 10° the line of membranous attachment is almost exactly along the margin which presents most directly for fenestration. An aperture made there may affect auditory vibrations and might be transmitted directly to the endolymphatic system rather than to the perilymphatic system.

The perilymphatic channel of the semicircular canals is poorly described in many texts, which give a lining of "endosteum." This term is really one for the marrow cavity of hollow bones, but has been diverted to the inner periosteum of cranial elements. Still worse, in the perilymphatic channels of the internal ear we must recognize a layer of arachnoid-like tissue against this "endosteum." Streeter, 1918, said that the perilymphatic spaces are not an extension of the subarachnoid spaces, as cited by Bast and Anson[4] in 1949. These authors say, "From the studies of the development of the subarachnoid and cisterns

From the William Waldo Blackman Laboratory of Anatomy, New York Medical College and Flower-Fifth Avenue Hospitals, New York.

by Weed (1917) and of the formation of the periotic tissue and spaces by Streeter (1918) it is apparent that they are essentially alike both in genesis and structure." "The continuity of the periotic spaces with the subarachnoid spaces is of interest." Streeter is cited: "the periotic spaces are analogous to the arachnoid spaces, but they are not identical with them, nor are they an extension of them." But Streeter adds that the aquaeductus cochleae, in a 130 mm fetus "can be plainly seen as a derivative of the arachnoid spaces." Bast and Anson continue, after this citation, saying, "had Streeter seen the duct and its connection with both the scala tympani and the arachnoid in the early stages of the development of the periotic tissue, for example, in a 40 mm fetus, his conclusions might have been different," since Streeter thought that the periotic duct in early stages did not communicate with the scala tympani (loc. cit.). And, further, across the adult perilymphatic passages we find vessels and nerves[5] with connective tissue trabeculae, suggesting the passage of nerve tracts through the subarachnoid spaces of the encephalon. All this may be disturbed in relations belonging to narrow cranium types having only slight lateral depression of the plane of the canal, if any release of the wall of bony investment results from operation. In the wide cranium we find 30° or even 40° lateral depression of plane.[2] This gives a safer exposure of the side wall of the bony tube encasing the membranous tube, since when the wall is opened the operator is not affecting the line of longitudinal attachment within the bony tube, nor tearing the nervous and vascular supplies. This note does not need to include histological details, although these are insufficiently given in many texts.[6,7]

The fact of the varied plane of the canal may possibly explain results, good in some cases, in others not so good.

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LXXXIV

A MODIFIED DESIGN FOR A EUSTACHIAN CATHETER

A. P. Seltzer, M.D.

Philadelphia, Pa.

The occasional difficulty in the catheterization of the eustachian tube is familiar to all otolaryngologists. The trouble may be in entering the tubal orifice successfully, or in keeping the catheter in position after entrance has been gained.

An attempt has been made to overcome these difficulties through alterations in the design of the catheter at present in general use (Fig. 1). The changes which have been made are simple, but they have proved effective in assuring greater ease and accuracy in introducing the catheter tip into the eustachian opening.

The basic design of the new modification is not notably changed, and the same material is used. The length may vary slightly from that of the familiar model, but the bore of the tube remains about the same.

One of the changes consists of the fitting of a B.-D. adapter to the outer end of the catheter, which receives the tube connected with the Politzer bag. This adapter is like that on the end of a hypodermic needle, and contributes to the security of the connection at this point.

A further addition is made by marking the catheter tubing in centimeters beginning at the inner edge of the adapter. This furnishes the means of accurately measuring the distance from the pharyngeal eustachian orifice to the border of the alae nasi.

There are two additional additions of particular importance. One is a small silver inner tube which is welded into the opening at the entering end of the catheter. This short silver tube extends outward one or two millimeters beyond the main shaft. It fits closely into

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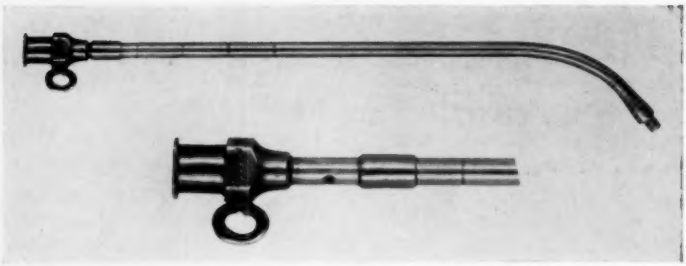
From the Department of Otolaryngology, Graduate School of Medicine, University of Pennsylvania.



the orifice, and the surrounding end of the metal shaft acts as a flange which aids in securing full closure of the tubal opening, and also prevents slipping. The silver tip is smooth and cannot tear tissues.

The second improvement of special significance is a small opening in the shaft of the catheter, about one millimeter in diameter and five millimeters from the lower edge of the adapter. In order that this opening may be either open or closed, a movable metal sleeve, seven millimeters in length, is placed around the shaft of the catheter and slides easily over or away from the small round opening described. The function of this opening in the wall of the catheter tube is to allow the escape of excess air or fluid which may be injected into the middle ear cavity. It acts in the nature of a safety valve, and thus avoids too great pressure. This safeguard is of particular importance when a compressed air tank is used, or when an electric motor is employed.

The advantages of the modifications of the eustachian catheter presented here can be summarized as follows:

1. The added tip aids in the insertion of the catheter into the eustachian tube and prevents it from slipping.

2. The small window in the shaft of the catheter removes the danger of injury to the ear drum from excess pressure when air or fluid is injected or instilled into the middle ear cavity.

3. The movable sleeve makes it possible to use the catheter with this escape aperture either closed or open.

4. The ruling in centimeters on the shaft of the catheter aids in later treatments when locating the eustachian orifice, if a primary record has been made.

5. Withdrawal by suction of any fluid accumulation within the eustachian tube or middle ear cavity. The sleeve is slipped back over the opening to facilitate better drainage.

Instrument manufactured by Pilling and Sons, Philadelphia, Pa.

2104 Spruce St.

LXXXV

WHY ARE SOME PATIENTS UNABLE TO LEARN ESOPHAGEAL SPEECH?

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The majority of patients who have undergone a total laryngectomy are able to re-establish speech soon after operation by learning esophageal speech. With expert supervision a few weeks are generally sufficient for mastery of the elements of the new speech, and a few more months are needed to gain the necessary experience for normal conversation.

Other ways to compensate for the loss of the larynx, pseudowhisper, pharyngeal and parabuccal speech, all fall short of esophageal speech in respect to loudness and naturalness. We also object to the use of an artificial larynx; intelligibility can be very good, but the sound lacks volume and naturalness and always betrays its mechanical source. The disguise is seldom as inconspicuous as the patient would like. Moreover, as a foreign body it can never become wholly part of the user.[6]

As a general rule one may say that esophageal speech can be learned by any patient who 1) has a strong enough desire to speak again; 2) is sufficiently intelligent; 3) is physically strong enough, especially in regard to his respiratory function; and 4) has not suffered too extensive anatomical damage by the operation or previous x-ray treatment. Difficulties are to be expected when muscles essential for esophageal speech have been removed, or deprived of their innervation. This applies also to secondary infection or x-ray treatment with formation of dense scar tissue; on the other hand a slight degree of rigidity may give good support to the deeper structures.

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Fistulae above the tracheostoma to the outer air are plainly inconsistent with esophageal speech.

However, there always remains a small number of patients, who meet the above requirements and yet do not learn to talk even with the most thorough training.

In the course of a research program on the mechanism of esophageal speech we came across a typical case of failure and were able to detect its cause and to establish esophageal speech. We report this case because it derives a general importance from the fact that anyone charged with speech revalidation of the laryngectomized patient may encounter difficulties of the same kind.

REPORT OF A CASE

The patient (F) was a young, healthy and powerful man, unable to learn esophageal speech. He was born in 1916, and had been treated by x-ray for carcinoma of the left vocal cord in 1953. Six months afterwards recurrence of the growth was detected, the entire left cord was affected, with almost complete fixation of the cord. Total laryngectomy was performed in March 1954 by Prof. Eelco Huizinga. Speech therapy started two weeks afterwards.

For several years the standard procedure of the logopedic department in Groningen has been to start with the syllables pa, ta and ka, as Mrs. Moolenaar-Bijl[7] has shown that the articulation of the voiceless plosives p, t and k facilitates the intake of air into the esophagus. With our patient, however, these syllables remained voiceless for a long time. It was also impossible for him to belch. Only after five days was the attempt for the syllable ta regularly accompanied by some sound; three repetitions could then be used as a start for any syllable beginning with a plosive (ta-ta-ta-kee, etc.). The light timbre, the high pitch and the small volume did indicate at that time that the voice did not originate from the esophagus, but from the pharynx. The patient could produce neither an initial vowel nor an intentional belch. Later, an initial vowel could be made following an inconspicuous movement with the tongue. Long series of syllables with p, t and k could then be uttered. After two months the patient had his voice always at his disposal. He was able, by slow and exaggerated distinct articulation, to keep up a conversation. The pharyngeal voice clearly had its drawbacks, the frequent short interruptions for the "loading" of the syllables, caused by the small capacity of the air-chamber, resulting in slow and scanning speech. The voice

Fig. 1.—Roentgenogram of laryngectomized patient during phonation: a patient with a very good esophageal voice, pseudoglottis at the level of the 6th cervical vertebra.

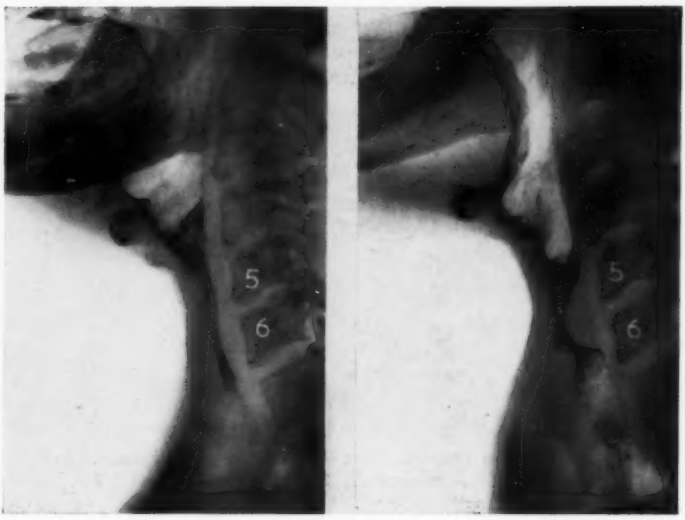
lacked carrying force and was very dull as it could not be modulated by melodic, dynamic or temporal accentuation. At later visits the voice seemed to gain some strength, but the other characteristics remained unchanged. The patient still could not produce a ructus voluntarily.

For more than a year this patient had to get along with this voice. Then the above mentioned research program led to some surprising discoveries.

DIAGNOSIS AND TREATMENT

This young and healthy man, who had undergone a not especially radical laryngectomy without any postoperative complications, showed a keen interest in the improvement of his voice, as the squeaking sound did not match his powerful physique.

Fluoroscopy was performed with the aid of a Philips x-ray image intensifier, which gives a clearer image than ordinary fluoroscopy,



A. B.

Fig. 2.—Roentgenogram of the patient dealt with in the text, a) with the old pharyngeal voice, pseudoglottis near the top of the 5th cervical vertebra, pulsating air chamber below the pseudoglottis to the bottom of the 6th cervical vertebra, empty esophagus, b) with the new esophageal voice, pseudoglottis near the top of the 6th cervical vertebra.

with a smaller x-ray dose. As a result details of the movement stand out far better, as only slight adaptation is required and the image can be perceived by fovial vision. (This apparatus also made possible the cineradiography of another patient, with a harmless x-ray dose.)

Fluoroscopy revealed that the generator was located between a protrusion lying on the anterior pharyngeal wall and its posterior wall (Fig. 2a). Below the pseudoglottis the hypopharynx was seen to be pulsating with each voiced sound, thus serving as a small air-chamber. The bottom of this air-chamber was found at the level of the 6th cervical vertebra. This is the region where one would expect the ridge of the sphincter that forms the esophageal mouth. No such ridge was visible, however; and the esophagus did not contain any air.

Van den Berg devised a simple functional test to measure the air-pressure in the esophagus at the moment when air begins to escape

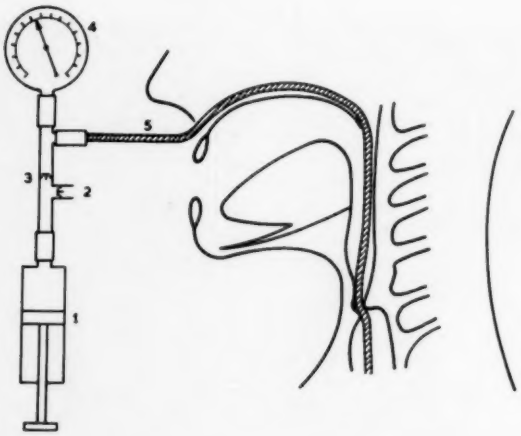


Fig. 3.—A simple functional test of the esophageal sphincter. 1: Syringe; 2 and 3: valves; 4: manometer; 5: catheter; (1, 2 and 3 can be replaced by a blood pressure balloon).

through the mouth of the esophagus (this pressure is analogous to the subglottic pressure in laryngeal phonation) (Fig. 3). A thin polyethylen catheter of 2 mm diameter and a bore of 1.3 mm with rounded end is inserted in the upper third of the esophagus through the nose. By means of a T-adaptor the catheter is connected to a membrane manometer and a syringe. When air is blown into the esophagus the pressure is seen to rise until the moment when the esophageal mouth begins to open and allows the air to escape, with or without sound. The pressure then falls back to a lower level and moves around a certain value as long as air is escaping. When the patient is instructed to open his mouth and to produce sound with the injected air it is possible to read the mean pressure during phonation. (Insufflation of air has been used by Botey, Seeman, Gatewood[3,5,9] and others as an auxiliary method in teaching esophageal speech. These investigators, however, did not use it as a functional test for the cricopharyngeal sphincter.) In good speakers pressures between 10 and 30 cm of water are found. In the case of this patient, however, the pressure had to exceed largely the measurable limit of the manometer (100 cm) before the air could escape with a resounding ructus. This confirms the patient's own experience during his postoperative speech training; he then had to drink two eight-ounce bottles of soda water before he succeeded in eructating. At any rate, an encouraging eso-

phageal sound was now heard, the air was not escaping through the cardia. An organic stenosis, resulting from the operation, which might form a barrier against the escape of air, was not likely since the man never had any swallowing complaints. Everything seemed to point to a functional spasm of the cricopharyngeal sphincter, or more exactly an inability to relax this sphincter voluntarily except during the act of swallowing. Therefore, treatment had to be directed towards abolishment of this reflex contraction.

A preliminary trial with drugs was not promising. There was no appreciable effect on the pressure level measured by the above mentioned method.

The patient was admitted for training in proper esophageal speech in December 1955. Esophagoscopy (by Prof. Eelco Huizinga) confirmed the radiographic findings: a small prominence on the anterior wall was seen; no obstruction was met lower down, the tube could be introduced with ease.

The following program was established: each morning the patient started by swallowing the thickest esophageal sound (weighted with birdshot). Then the small catheter was introduced in the described manner and air was pumped into the esophagus. At first he was instructed simply to allow the air to escape, without attempts at phonation. By looking at the manometer he had to try to reach the lowest possible pressure. The purpose of soundage and air injection was to make the patient conscious of dilatation and relaxation of the mouth of the esophagus. After a few days the pressure was much lower (30-50 cm of water).

During other sessions he was taught how to take in air by himself. The method of starting with plosive consonants was not applicable here, as this only forced the patient into his old spasmodic way of speaking. It was not possible for him to relax his sphincter sufficiently while making a positive pressure above it. We believe that the crucial problem of learning esophageal speech lies in the reconditioning of the natural reflex which keeps the entrance to the esophagus shut against a high air pressure above it.

Besides the intake of air by "injection," some laryngectomized patients use "inhalation," which is not quite as good. This also caused the patient much trouble. In the beginning he could draw a sufficient amount of air into the esophagus only by swallowing with closed

nostrils, as he himself had discovered. We encouraged this, as it might accustom him to the passage of air through the mouth of the esophagus. At the same time we made him relax the muscles of the jaw and neck, which were very tense during any effort at speech. We hoped that the tension of the less consciously controlled muscles of the hypopharynx would diminish simultaneously.

In order to learn to dilate his pharynx maximally, he had to practice yawning regularly. This was not easily accomplished. A real yawn reflex could only be provoked by repeatedly going through the movements of deep inspiration with outstretched arms and wide open mouth together with the example of his teacher.

In this stage air entered easily into the esophagus when he held his tracheostoma closed with a skinfold while yawning. This is easy to understand as the air pressure in the thorax, and consequently in the esophagus, becomes highly negative during inspiration and highly positive during expiration with a closed tracheostoma. These pressure differences were just sufficient to make the air enter the esophagus during inspiration and to press it out during expiration. In this way, with the tracheostoma held closed and after yawning, he succeeded in speaking his first words, without air being blown in by way of the catheter. This was soon possible without closing the tracheostoma; he still held his hand to his throat, but this served only to improve the sound by a slight external pressure upon the mouth of the esophagus.

After three weeks on the ward he was discharged. Fluoroscopy showed that there was now a wide gap at the site of the former pseudoglottis; the new pseudoglottis was at the mouth of the esophagus (Fig. 2b). After continued ambulatory treatment for one month he was able to use his voice satisfactorily for conversation and afterwards he learned to use the plosive consonants method.

SUMMARY

A few laryngectomized patients are unable to learn esophageal speech without an apparent cause. A typical case is reported in this paper.

A young, healthy and powerful man failed to learn esophageal speech. His failure appeared to be due to a lack of relaxation of the cricopharyngeal sphincter.

A special treatment is described which transformed his former inadequate pharyngeal voice into a satisfactory esophageal voice.

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LXXXVI

MECHANISMS IN THE DEVELOPMENT OF POST-INTUBATION GRANULOMAS OF THE LARYNX

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Post-intubation granulomas of the larynx after endotracheal anesthesia occur once in every 800 to 1000 cases.[1] Previous authors have considered trauma, lack of experience and lack of skill to be the predisposing causes.[2,3] It is seldom appreciated, except by anesthesiologists, that the trauma of difficult intubations does not often occur at the vocal cords but rather, higher in the respiratory passages. In nasal intubations, especially, the difficulty lies not in introducing the tube through the cords but rather in placing the tube at the glottic opening.

A previous study of postintubation granulomas suggested that an abnormal position of the head during the operation was the principal cause. Accordingly, a review of cases previously reported in the literature was undertaken to see if these results were substantiated.[4-13] Because of lack of certain specific points a variable number of cases was obtained for analysis. They have been compared with the results obtained by the authors in a previous study of seventeen cases at Memorial Hospital plus an additional three cases from the same institution.

RESULTS

Because of insufficient pertinent data in previously recorded cases of postintubation laryngeal granulomas, varying totals of cases are available for analysis in the different categories. Myerson[14] has reported that ninety per cent of granulomas occur in females which is borne out by Table I which represents the number of cases in which the sex was recorded.

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TABLE I

	FEMALE	MALE
Howland and Lewis	18	2
Literature	20	3
	38	5

OPERATION

The highest incidence of granuloma formation occurs in head and neck surgery (Table II). Of 35 patients available for study in which the operation was recorded, 21 cases were in this category. Of these 21 cases, 14 occurred in patients undergoing operations on the thyroid gland. Thus, over one-third of the total number of granulomas occurred after one type of operation. In only 4 of the cases was the patient's head in a neutral, unextended or mid-line position. In 21 cases the head was extended, in 5 cases the patient was in a lateral position, in 4 cases the patient was in Trendelenberg and in one case the patient was prone for a laminectomy.

TABLE II

	HOWLAND AND LEWIS	LITERATURE	TOTAL
Head and Neck	13 (11 thyroid)	8 (3 thyroid)	21
Chest	4 (1 Bilateral Radical Mastectomy)	2 (Total gastrectomy)	6
Pelvic	2	2	4
Upper abdomen	0	2	2
Prone	0	1	1
Operation cancelled	1		1
	20	15	35

ANESTHESIA AND INTUBATION

In the cases in which the route of intubation could be determined there were 20 nasal intubations (4 blind) and 13 oral intubations with direct visualization of the larynx. There was difficulty in intubation in only 5 cases of which 3 were by the blind technique. In one patient not operated upon, bronchospirometry was discontinued because of inability to insert the tube between the vocal cords.

The anesthetic agents used were pentothal, 18; ether, 10; cyclopropane, 2, and topical, 1.

DEVELOPMENT OF GRANULOMA

The interval from operation to the development of the granulomas varied from 2 weeks to 28 weeks (Table III). The majority of the lesions, 22 cases, were discovered by the eighth week. Ten of the patients had some focus of upper respiratory tract infection prior to or immediately following surgery.

TABLE III

DEVELOPMENT OF GRANULOMAS

WEEKS POSTOPERATIVELY	LITERATURE	HOWLAND AND LEWIS
2 weeks	3	2
4 weeks	1	2
5 weeks	3	0
6 weeks	3	2
7 weeks	0	1
8 weeks	1	4
10 weeks	0	2
12 weeks	2	5
16 weeks	0	1
24 weeks	2	0
28 weeks	0	1
	15	20

ANATOMICAL LOCATION

A total of 15 patients had bilateral lesions and 1 patient had 3 granulomas. There was a total of 50 granulomas of which 3 were on the anterior one-third of the vocal cord, 10 were on the middle one-third and 37 occurred on the vocal process of the arytenoid cartilage (Table IV). Twenty-eight of the patients had their granulomas removed operatively and 6 cases responded to conservative treatment.

TABLE IV

LOCATION	HOWLAND AND LEWIS	LITERATURE	TOTAL
Anterior one-third	3	0	3
Middle one-third	6	4	10
Posterior one-third	17	20	37
	26	24	50

COMMENT

Previously, trauma has been considered to be an important consideration in the development of postintubation laryngeal granulomas. However, long association with anesthesiology residency training programs does not substantiate this belief. Traumatic intubations in the hands of the novice are not unusual. Similarly, granulomas have not been reported after bronchoscopies by fledgling otolaryngologists. The etiology must be sought elsewhere.

The highest incidence of granulomas occurs after head and neck surgery during which the head is extended, often with pillows or sandbags under the shoulders of the patient. This position places the larynx at a considerably higher level than the head thus forcing the endotracheal tube against the posterior portion of the glottis. Twenty-one of the 34 cases were in patients who had their head extended and in the one patient in the prone position an abnormal position of the head certainly occurred. In only 3 of the cases was the patient in a supine position with the head unextended. These operations were bilateral radical mastectomy, cholecystectomy and exploration of the common duct.

Six of the granulomas occurred in chest cases in which the patient was in the lateral position and 4 patients were in Trendelenberg for pelvic surgery.

In only one patient could the development of the granuloma be directly attributed to trauma. In this patient bronchospirometry was discontinued because of inability to insert the tube between the vocal cords. One week later the patient was hoarse but laryngoscopy revealed no granuloma. Six weeks postintubation a granuloma was discovered on the anterior one-third of the right vocal cord.

The incidence of pre-existing respiratory infections in patients who develop postintubation granulomas may be significant, especially as a source of irritation to an abraded laryngeal mucosa. However, it must be borne in mind that in all of the cases reported by the authors the patients received antibiotics postoperatively.

The route of intubation has apparently little influence on the development of granulomas. Twenty of the patients were intubated nasally and 13 of the patients by the oral route.

In the 31 cases in which the anesthetic agent could be determined granulomas occurred in 18 of the patients intubated with pentothal,

12 in patients intubated with general anesthesia and 1 with topical spray. The usual anesthetic technique in operations about the head and neck in most clinics is that of pentothal plus a supplemental agent usually nitrous-oxide and oxygen.

The time recorded for the development of the granulomas postoperatively was usually when the patient complained of symptoms of hoarseness or respiratory obstruction. This time varied from 2 weeks to 28 weeks. Twenty-two of the 35 cases had occurred by the end of the eighth week. In one case the larynx was negative at the end of the sixteenth week but a pathologically proved pyogenic granuloma had developed by the twenty-eighth week.

The development of postintubation granulomas occurs in certain conditions. These are an abnormal position of the head during the operative procedure, the presence of existing acute or chronic respiratory infection, and the size of the larynx in relation to the endotracheal tube.

The higher incidence of granulomas in female patients may be explained by several factors. Females have a smaller larynx than the male, the mucosa of the true cord in the female (59 microns) is approximately half as thick as in the male (97 microns),[15] and finally the operations in which the head is in an abnormal position occur with greater frequency in females than in males.

SUMMARY

1. A review of analyzable cases of postintubation laryngeal granulomas has been made.

2. This condition occurs in a ratio of 7 females to 1 male.

3. Granulomas may occur on the vocal cords elsewhere than on the vocal process of the arytenoid cartilages.

4. Possible causative mechanisms have been discussed.

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LXXXVII

HEMANGIOMA OF THE NASAL BONE

REPORT OF A CASE

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Hemangioma of the nasal bone is a very rare condition. A perusal of the literature reveals that prior to this report only two such cases have been recorded. Neivert and Bilchick[8] reported the first case in 1936. Bloom[2] reported the second case in 1954. No case has been reported since 1954.

Toynbee[9] in 1842 gave the first description of vascular tumors of the parietal bones. Hitzrot[3] in 1917 gave the first report of roentgen examination of primary hemangioma of bone. Anspach[1] in 1937 reviewed the literature, disclosed a total of 21 reported cases of hemangioma of the skull, and reported an additional case of his own, emphasizing the special roentgen features. Of the 21 cases of hemangioma of the skull cited by Anspach, only 7 cases were operated upon, and in these the diagnosis was made only postoperatively.

Kaplan and Kanzer[5] in 1939 reported the first case of hemangioma of the parietal bone diagnosed preoperatively by roentgen examination.

Kelemen and Holmes[6] in 1948 gave an excellent review of the literature, with particular reference to hemangioma of the frontal bone. In all the cases reviewed, they found only two or three cases in which the hemangioma was limited to the frontal bone. They reported an additional case of hemangioma confined to the frontal bone. In 1952, Holmes, Sweet and Kelemen[4] reported three more cases of hemangioma of the frontal bone. The diagnoses were made preoperatively in all cases, and, in three of the four cases, the lesion was removed surgically.

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REPORT OF A CASE

A 47-year-old white housewife was admitted to the New York Hospital on October 27, 1954. The patient had a tender swelling over the right side of her nose, which had increased in size gradually during the past two and one-half years. Of late, the swelling had increased in size more rapidly and had become somewhat more tender. She also complained of some frontal headache on admission. There was no history of trauma to the nose or face.

The patient gave a history of rheumatic fever as a child, with slight heart enlargement. She took digitalis for several years, but had taken no digitalis for the past 18 years. The patient denied having had any operations. Otherwise, the past history was essentially negative.

The patient first noted the slight swelling over the right side of her nose approximately two and one-half years prior to admission. The swelling had gradually increased in size and became somewhat tender. For about six months prior to admission, she had noted a more rapid increase in size and increased tenderness of the swelling.

The patient was a well-developed white female in no distress. The general physical examination was essentially negative. Examination of the heart showed a regular sinus rhythm and no demonstrable heart enlargement by percussion. There were no murmurs. The blood pressure was 130 systolic and 78 diastolic. The lungs were clear. Local ear, nose and throat examination showed the tympanic membranes to be normal in appearance. The nasopharynx was clear. Examination of the throat was essentially negative. Examination within the nose was essentially negative and the sinuses were clear.

Examination of the external nose revealed a hard tumor mass over the right nasal bone, extending beyond the midline and involving the median third of the left nasal bone. The tumor mass measured approximately 1½ cm in diameter. The mass was slightly tender to palpation.

X-rays of the skull and nasal bones were taken. Examination of the skull in multiple projections failed to reveal any evidence of abnormality. Lateral roentgenograms of the right nasal bone revealed a bony tumor involving the major portion of the nasal bone. The tumor showed the typical sunray or sunburst pattern, with numerous fine reticulated lines arising from a common center and at right

Fig. 1A.—Preoperative photograph showing extent of swelling over right nasal bone.

Fig. 1B.—Photograph 18 months postoperatively. Photograph shows a minimal scar with good cosmetic result.

angles to the plane of the nasal bone. The bone appeared considerably widened. However, the margins of the tumor were smooth.

The x-ray diagnosis was: findings are consistent with hemangioma of the nasal bone.

Laboratory tests were negative.

On October 28, 1954, excision of the tumor was carried out under general endotracheal anesthesia.

The patient was prepared and draped in a routine manner. A slightly curved incision was made through the skin over the right nasal bone, extending from approximately the level of the right inner canthus to just below the lower border of the right nasal bone. The soft tissues were reflected from the tumor mass by blunt and sharp dissection. A 2 cm bony tumor was exposed, arising mainly from the right nasal bone, but also involving the median third of the left nasal bone. The periosteum over the tumor was remarkably thinned and frayed. The surface of the tumor was to some extent loculated and had a slightly purplish cast. The bony tumor was removed by encircling the tumor with the power-driven perforating burr, taking care to remove an adequate margin of normal bone on all sides.

The tumor was lifted from its bed with relative ease. This resulted in a slight rent in the nasal mucous membrane, which was sutured with ease. A moderate defect was left in the area previously

Fig. 2.—Lateral roentgenogram of nasal bone showing characteristic sun-ray or sunburst pattern with trabeculations which radiate from a common center and away from the plane of the nasal bone.

occupied by the tumor. This defect was corrected, using a double layer of septal cartilage removed for this purpose.

The tissues were returned to their normal position and the skin closed with multiple fine silk sutures. There was minimal bleeding encountered in removing the tumor by encirclement and cutting through the nasal bone. A dry sterile dressing was applied and the patient returned to the recovery room in good condition.

The postoperative course was uneventful. Combiotic with streptomycin 0.5 gm twice daily was given. The silk sutures were removed on the fourth postoperative day. The patient was discharged on the sixth postoperative day.

The patient was followed postoperatively and on her last visit (4/13/56) there was no evidence of recurrence and the cosmetic result was good.

Pathologic Anatomy. The single piece of excised bone measured 2 x 1.3 x .8 cm. On one surface there is a thin plate of cortical bone

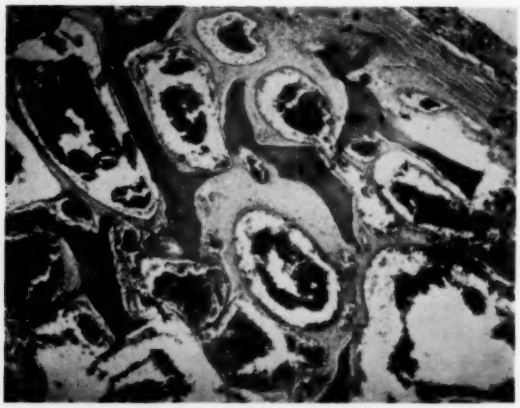

Fig. 3.—Photomicrograph of section stained with hemotoxylin and eosin (x 70). Section shows large blood lakes, areas of necrosis of bone, radiating spicules and remnants of connective tissue and endothelial proliferation. The above is characteristic of the lesion and represents a typically cavernous structure.

in which there are defects extending into the underlying spongy bone that makes up the remainder of the specimen. The material in the trabecular spaces is red or blue and soft.

The lesion is a cavernous hemangioma. Under the microscope, in the central portion of the excised bone, the marrow spaces are found to be almost entirely replaced by large pools of blood sursounded by endothelium. More peripherally, there is an area of loose acellular fibrous tissue between the cavernous channels and the surrounding bone. In these regions there is some osteogenesis, as indicated by osteoblasts and newly formed osteoid. In the central areas where the sinusoids are largest and most numerous, the bony spicules are small, as if atrophied. There is no cushion of connective tissue here separating the vascular channels from the bone. Only a layer of flattened endothelial cells separates the surfaces of the trabeculae and the blood spaces. Often a blood vessel lies in a niche in the bone, as if actually eroding. In some regions, there is definite destruction of bone, but there are no osteoclasts. On the lateral margins, the cortex has been invaded and much of it has been destroyed and replaced by tumor. The periosteum, however, although thin, is intact and stretches over the expanding lesion.

The endothelial cells of the tumor vary little in size or shape. There is no anaplasia whatsoever. All the cells lining the large cavernous vessels are flattened and elongated, sometimes being almost imperceptible. In the smaller capillaries at the edge of the lesion, in fact, in the normal bone, the endothelial cells are sometimes swollen and plump with easily visible cytoplasm. Although probably tributaries to it, these can hardly be considered a part of the hemangioma. In spite of the erosion of bone, there is no cytologic characteristic of the tumor endothelial cells to suggest malignancy.

This tumor is essentially similar to the one described by Neivert and Bilchick and to the one reported by Bloom—the only two hemangiomas of the nasal bone that could be discovered in the reported records. It is also much like the cavernous hemangiomas of the frontal bone described by Kelemen and Holmes and by Holmes, Sweet and Kelemen, who were able to add four cases to the only two they could find in the literature previous to 1952.

Diagnosis: Hemangioma, nasal bone.

COMMENT

The etiopathology of hemangioma of the nasal bone is unknown. Trauma has been cited as a possible factor in many cases of hemangioma of bone in general. However, there was no history of trauma in the above case or in the case reported by Neivert and Bilchick. Trauma is cited as a possible factor in the case reported by Bloom. There was no history of trauma in the three cases of hemangioma of the frontal bone reported by Holmes, Sweet and Kelemen, although there was a history of trauma in the fourth case reported by Kelemen and Holmes previously. Meda[7] has pointed out the possible relationship of hemangioma of bone with the vascular and hormonal changes which take place around the climacteric. It has been pointed out that hemangiomas of bone are most frequent in the fourth and fifth decades and usually occur in the female. However, the lesion has been found to be congenitally present in the newborn and also to have been found at autopsy in older individuals as much as 90 years of age.

The patient discussed in this report was a woman around the climacteric age. There was a similar situation in the three cases of hemangioma of the frontal bone, reported by Holmes, Sweet and Kelemen.

With regard to histogenesis, it is interesting to note that the nasal bone is generally believed to develop from a single ossific center. In

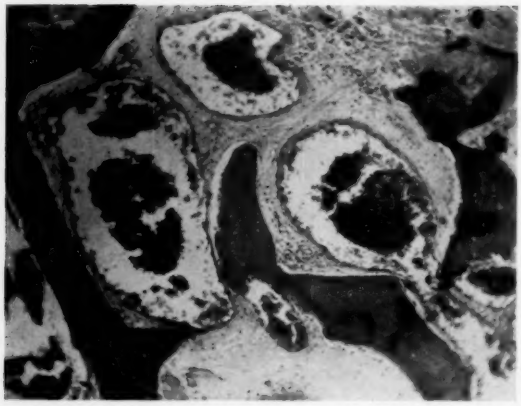

Fig. 4.—Photomicrograph of section stained with hemotoxylin and eosin (x 120). Section shows the large endothelial lined cavernous blood-filled spaces lying between the spicules. The supporting stroma of myxomatous fibrous tissue is well seen. On the right margin of the center spicule, one can clearly see a row of osteoblasts.

all of the three cases of hemangioma of the nasal bone, the site of the lesion was the right nasal bone.

Although the majority of hemangiomas, especially those on the surface of the body, are thought not to be the true neoplasms but rather congenital malformations or vascular hamartomas, this lesion in the nasal bone appears to be an acquired tumor that arose by proliferation and enlargement of the capillaries in the marrow spaces. The encroachment on the trabeculae causes atrophy of the bone and gives rise to the typical sunray appearance in the roentgenograms. Reparative regeneration of bone also plays a part.

SUMMARY

One case of sunray hemangioma of the nasal bone is reported. A survey of the literature reveals that only two cases had been reported previously.

The lesion was removed surgically and normal bone about the lesion was included in the excision. The diagnosis was made preoperatively by roentgenogram and confirmed by microscopic examination. The surgical defect was corrected immediately by cartilage graft taken from the nasal septum.

The growth appears to begin in the vascular spaces of the bone. It enlarges by the expansion of existing blood vessels and the formation of larger blood lakes.

The cortex is eventually penetrated, but the lesion does not extend beyond the periosteum, which, although stretched and frayed, remains intact. Some of the bony trabeculae are absorbed, while others are thickened to form the radiating spicules, which are responsible for the characteristic sunray appearance of the lesion by x-ray. The tumor is benign and does not metastasize. Incomplete removal, however, invites renewed and increased growth on the part of the tumor.

Treatment is surgical and consists in complete excision of the tumor with a margin of normal bone. This form of treatment minimizes bleeding and prevents recurrence.

525 E. 68TH ST.

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Scientific Papers of the American Otological Society

LXXXVIII

THE RESTORATION OF THE FUNCTION OF THE MIDDLE EAR, IN CHRONIC OTITIS MEDIA

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In all radical mastoidectomies the aim of the otologists has been, not only not to disturb the hearing ability but, if possible, even to improve it. In order to achieve this goal damage to the inner ear through infection had to be prevented, and on the other hand, great care had to be taken to keep the sound conducting structures of the middle ear, if possible, intact.

We all know from our own experiences and from large statistics, that in the treatment of otitis media this aim had met with very limited success. Only in certain operations, for instance, in very small cholesteatomas in Prussack's space was it possible to preserve good hearing or even to improve it. A systematic restoration of the function of the diseased ear has, however, been absolutely impossible.

The development of microsurgery, since Gunnar Holmgren, and the modern control of infections through antibiotics and sulfonamides, has opened completely new possibilities in otology. The increasing success of the operative treatment of otosclerosis, to which American authors have made such splendid contributions, led to attempts at overcoming in a similar way the functional damage to the sound conducting mechanism of the middle ear in chronic otitis media.

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Each operation with this goal must fulfill several tasks. The chronic infection must be eliminated completely and all complications must be definitely prevented. One must build a new, air filled, closed tympanic cavity which is properly ventilated through the tube. At the same time, a new system for conduction of the acoustic stimuli through the middle ear to the cochlea must be constructed. This system must be modified according to the extent of the destruction of the middle ear. As a result of this, these operations, which I have named "Tympanoplasty" require in contradistinction to the fenestration operation continuous variations.

It is difficult to give the indications for the different types of tympanoplasty. On the other hand contra-indications are only a few: 1) Complications of the middle ear infection which are a danger to life. 2) Inadequate function of the inner ear, so that an improvement of the sound conduction in the middle ear will be without result.

Complications of this type are infections of the meninges or of the lateral sinus, especially extensive osteitic changes in the labyrinthine capsule and cholesteatoma of the inner ear. An uncomplicated labyrinthine fistula that means a circumscribed stationary osteitis of the labyrinthine capsule, does not preclude tympanoplasty.

Tympanoplasty will be unsuccessful even after reconstruction of the middle ear if the inner ear function is insufficient for understanding of speech. The lower limit of inner ear function for tympanoplasty is the same as the well known limit for fenestration.

The clinical factors which constitute the indications and prognosis for tympanoplasty are according to their audiological significance the following:

1. Quality of the inner ear
2. Function of the tuba auditiva
3. Hydrodynamics of the inner ear
   a) Function of the round window
   b) Function of the oval window
   c) Function of the new window
4. Quality of the mucosa
5. Quality of the tympanic membrane
6. Ossicula

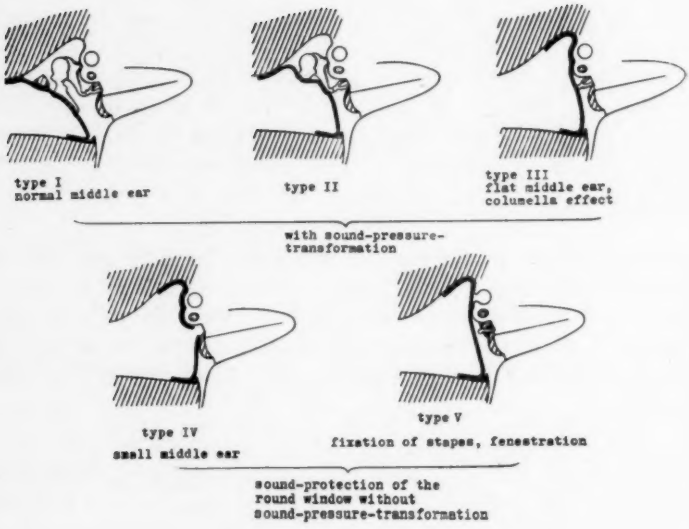

Fig. 1

For reconstruction of the damaged middle ear the following operative goals are of prime importance: The restoration of the hydrodynamics of the inner ear in the scala vestibuli through the oval window or through creation of a new window in the lateral semicircular canal and in the scala tympani, through the round window niche and membrane; restoration of the proper function of the tube; reconstruction of an air-filled tympanic cavity, covered with mucous membrane and free from epidermis; implantation of a graft in very severe infection or extensive defect of the mucosa; creation of sound protection for the round window and, if possible, restitution of sound pressure transformation to the oval window through substitution of the partly or totally defective tympanic membrane.

Reconstruction of the damaged middle ear can be achieved, for operative-technical and audiological reasons, in five different ways, depending on the extent and the location of the pathological changes.

cause of the defect of the malleus and incus, must sacrifice the chain and with it the epitympanum. A narrow middle ear cavity with only very little distance between tympanic membrane and promontory will result. Both the upper ventilation channel, from the tubal corner below the tensor tympani muscle to the oval window, and the lower ventilation channel through the hypotympanum into the round window niche, should, however, remain completely open. In the Types 4 and 5 only a small tympanic cavity can be built, consisting of tube, hypotympanum and round window niche, i.e., only of the lower ventilation channel.

In Type 5, in addition to that, a new window must be made into the lateral semicircular canal, replacing the blocked oval window. All pathological situations found in restorative operations, without exceptions, including fenestration, mobilization and operations for atresia of the external auditory meatus and middle ear malformations, can be grouped in these types.

How can the proper type of tympanoplasty be chosen and carried out? The chronic otitis media must be examined, as before, with regard to the underlying pathology. But neither a marginal perforation, nor cholesteatoma, nor purulent secretion nor a fistula symptom are contra-indications for a tympanoplasty. The patency of the tube should be examined before operation. But in the presence of extensive adhesions in the mesotympanum, or in a middle ear cavity filled

Types 1-3 aim not only at sound protection for the round window, but also at restoration, as far as possible, of the effect of the sound pressure transformation on the oval window. Types 4 and 5 limit themselves to the sound protection of the round window. Types 1 and 2 preserve the attic and the ossicular chain. In this way the mesotympanum can be preserved in its normal depth. Type 3, be-
with cholesteatoma behind large remnants of the tympanic membrane, absence of tubal patency is no definitive proof that the tube is actually closed in its cartilaginous or bony portion.

The threshold audiogram must show the typical large gap between bone and air conduction, if a marked hearing gain is expected from the restoration of the middle ear. But in contra-distinction to otosclerosis a tympanoplasty can also be done in cases with a very good air conduction curve and only a small middle ear com-

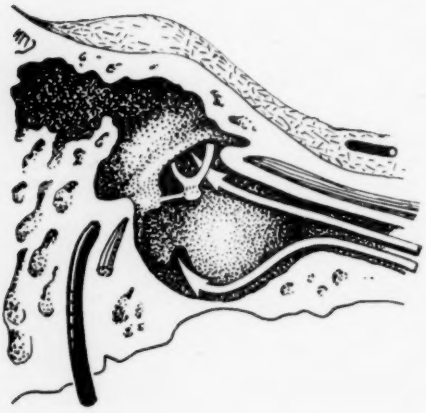

Fig. 2

ponent of the hearing loss. The indications for the operation of a chronic otitis media have so far changed that we now want a definitive cure as long as the destructions are not too extensive, for example, in cases with small cholesteatomas or central perforations. It is also possible that a chronically infected middle ear, in spite of good hearing ability, is anatomically and audiologically very defective, for instance, in cases where a cholesteatoma behind a small perforation in the drum has damaged the ossicula right up to the stapedial footplate, but where the sound conduction takes places through the masses of cholesteatoma.

Indispensable in the examination is the test with an artificial tympanic membrane. Not at all times will this test be successful at the first attempt; but if repeated examinations show at least at one time a marked hearing increase in the audiogram, it is proven with certainty that both labyrinthine windows are properly functioning. If this examination is negative again and again it is still no definite proof that the stapes is fixed or the round window membrane is immobilized. Fixations in the epitympanum or blockage in the hypotympanum through granulations might be the cause of it. For this reason the acoustic probe of Pohlman has been developed into an

electro-acoustical instrument, by Zöllner. In cases with a narrowed auditory meatus, with extensive adhesions, with an almost preserved pars tensa of the tympanic membrane and heavy scarring in the mesotympanum it is not possible for the acoustic probe to reach the critical measuring points before the operation is done. Besides, there are often several audiological obstacles, for instance, interruptions of the ossicular chain and at the same time fixation of the stapedial footplate. The difference in the bone conduction measurements are not always unequivocal enough to permit a correct diagnosis. In chronic otitis media the situation is in all respects fundamentally different from that in otosclerosis. In otosclerosis with a clear-cut indication for operation one is practically always confronted with a stapedial ankylosis, with an obstruction in the oval window. On the other hand in chronic otitis media, the obstruction can be located in the oval or in the round window or in both.

For that reason and from experience gained in about 500 tympanoplasties, I have reached the conclusion that only a careful examination of every part of the structures of the middle ear during operation and under strong magnification will make it possible to recognize the type of functional disturbance present and to select the proper type of tympanoplasty, and furthermore, if several functional disturbances are present, to decide which of them would determine the type of tympanoplasty to be performed in any particular case.

A very successful tympanoplasty with narrowing of the air-bone conduction gap to about 5 db is most frequently performed when the structures of the middle ear are completely intact, as in Type 1. In Type 2 and more often in Type 3, the number of these ideal results will be lower, and in Type 4 and 5 they will become theoretically impossible. It is, therefore, of the greatest importance to check the whole structure of the middle ear for pathological changes, but by no means to destroy it. In a total defect of the tympanic membrane it is easy to get an over-all view. In smaller defects of the tympanic membrane care should be taken not to enlarge the perforation and also not to lift the membrane out of the annulus osseus. Because of the perforation it would lose its tension and stiffness and, therefore, its usefulness for the sound-protection, the sound pressure transformation would be markedly reduced. To check the whole structure of the middle ear without damage to its function I am using three views:

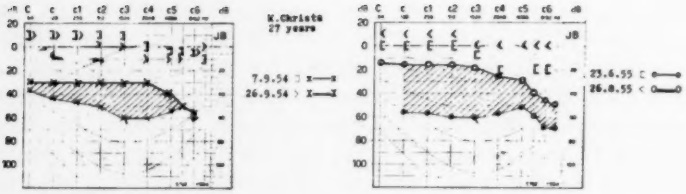

Fig. 3.—Malformation of the external and middle ear. 8.9.54 Tympanoplasty type III. Chain deformed, malleus fixed in the attic without contact with the tympanic membrane, very small incus, staff-like small stapes, mobile. Plastic-columella. Free skin-graft. 22.7.55 Tympanoplasty type V with Fenestration. Defect of malleus and long process of the incus. Stapes fixed by bone on facial-nerv-side, round niche free. Fenestration. Skin-graft.

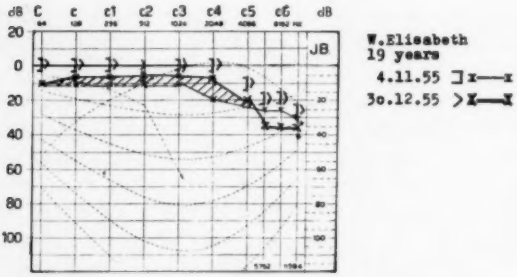

Fig. 4.—10.11.55 Tympanoplasty type III. Defect of the membrana flaccida, pars tensa preserved, cholesteatoma in the attic, matrix enclosing the ossicles. Bony bridge, incus and head of the malleus removed. Free skin-graft.

1. *The control of the antrum.* After slight enlargement of the external auditory meatus with a burr, the antrum behind the bridge will be opened through a drill hole, and in this way the epitympanum with the short process of the incus can be viewed from behind.

2. *Control of the upper portion of the middle ear.* Shrapnell's membrane participates in the closure of the middle ear but not in the transformation of the sound pressure. I remove Shrapnell's membrane and then with diamond burr a small marginal portion of the bridge. From here the epitympanum can be controlled from the front, especially the weakest part in the chain of ossicles, the long process of the incus. It must always be looked for first, because at this point, through granulations or cholesteatoma in the narrow space between bridge and facial nerve, the sound conducting chain is often interrupted. From this place we also examine the stapes. If the oval niche is filled with granulations the head of the stapes together with the stapedial tendon is embedded in them. If one exposes the niche one might find that both crura of the stapes are destroyed by granulations and that the head only, like a trap, is attached to the long process of the incus and the tendon of the stapes.

3. *Control of the lower middle ear.* The lower view into the middle ear makes it possible not only to control the sinus tympani below the processus pyramidalis and to look into the oval niche, but especially to control the round window niche, if necessary to view directly the round window membrane and the whole hypotympanum.

For many years I have been using the lower control of the middle ear also in all fenestration operations for otosclerosis. The tympanic membrane is left untouched in its annulus osseus and, therefore, its function as a sound protector for the round window remains unimpaired.

Since nowadays in all marked conductive losses there is indication for an operative improvement, not only extensive otosclerotic changes of the promontory with pronounced narrowing of the round window niche but also inflammatory closures can be recognized in this way.

The control of both labyrinthine windows can be carried out without removal of the head of the malleus or the incus. The method

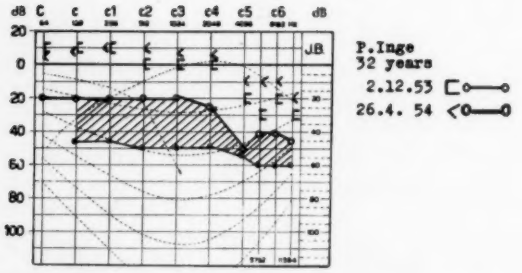

Fig. 5.—Otosclerosis (?) Tympanic membrane intact. 4.12.53 Tympanoplasty type I. Bony bridge and chain preserved, only adhesions in the round window niche, removed. Stapes mobile. Aditus ad antrum closed with free skin-graft.

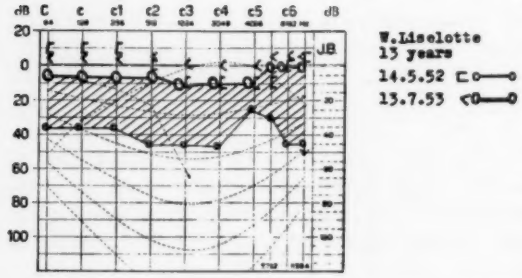

Fig. 6.—Complete defect of the tympanic membrane, secretion. 24.9.52 Tympanoplasty type I. Ossicular chain intact, round niche closed by granulations, implantation of amnion. Free skin-graft. 13.7.53 New tympanic membrane mobile.

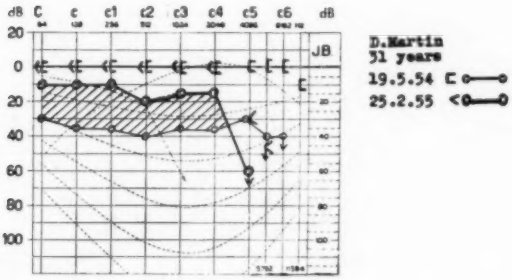

Fig. 7.—31.5.54 Tympanoplasty type II. Cholesteatoma, small perforation of the membrana flaccida. Defect of the head of malleus. Bony bridge partly preserved, protecting the incus. Large labyrinthine fistula freed from matrix and endosteum. Skin-graft covering also the fistula. 25.2.55 New tympanic membrane mobile.

described is definitely worthwhile, because one-fourth of all tympanoplasties belong to Type 1, between 15 per cent and 20 per cent to Type 2, both together comprise, therefore, two-fifths of all these operations. I want to point out that in 500 operations, which were performed to study this method, I have operated on all cases of chronic otitis and of adhesive changes and all cavities after radical mastoidectomy as tympanoplasty, unless there had been a direct contra-indication. There had been no selection of favorable cases.

If both outer parts of the chain, malleus and incus, are too much destroyed, they must be taken out and with them almost every time, the bridge. Zöllner has called the direct transmission of sound to the stapes in adhesive processes or by operation a columella-effect, Juers, myringostapediopexie. But already in 1901 Mathe had accomplished and published the operative reposition of the drum membrane to the head of the stapes for the restoration of sound conduction. The audiological difficulties for the sound pressure transformation become much greater in this type, even if the greater part or the whole pars tensa had been preserved (for instance in cases of operative defect of the incus because of previous simple mastoidectomy); a retroposition of the tympanic membrane to the head of the stapes requires a wide lifting of the drum out of the annulus osseus, especially also on the upper circumference. The preserved portions of

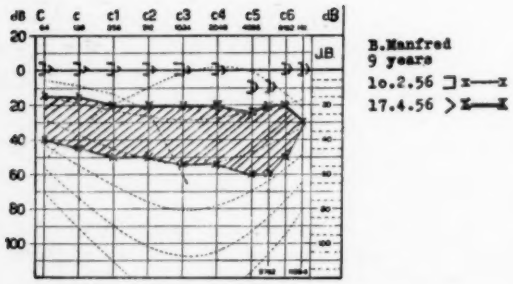

Fig. 8.—27.3.56 Tympanoplasty type III. Cholesteatoma in the attic, defect of the handle of malleus and of the long process of the incus. Bony bridge, incus and malleus removed. Free skin-graft.

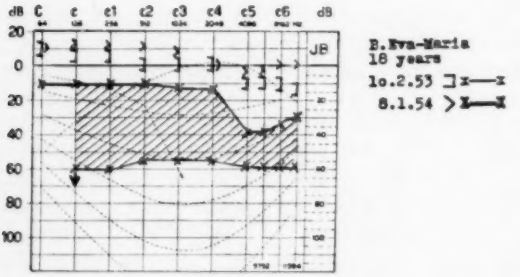

Fig. 9.—1942 Mastoidotomy as child, incus removed. Tympanic membrane intact. 14.2.53 Tympanoplasty type III. Retroposition of the tympanic membrane, stapes-columella. 30.4.53 New tympanic membrane mobile.

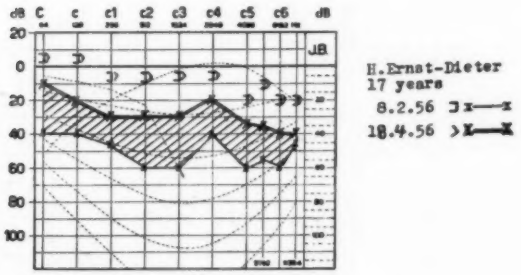

Fig. 10.—Tympanoplasty type IV 12.3.56. Large marginal perforation, defect of the handle of the malleus, of the long process of the incus and of the stapes. Free skin-graft split over oval niche.

the collagenous fibres suffer through this deformation. Therefore, the proportion of very good audiological results is relatively small in this type, which comprises about one-third of all tympanoplasties.

Defects of the stapedial crura are found in about 10 per cent to 15 per cent of the cases in this type of operation. We have here two possibilities, either to insert an artificial columella, or to keep the oval niche open towards the external auditory meatus; that means the sacrifice of all sound pressure transformation and operative restoration of the sound protection for the round window only, as it had been suggested by Moritz. This method is simpler and audiologically very dependable and efficient, just as in Type 5 the restoration of the sound protection and the substitution of the oval window through a labyrinthine fenestra. Even without sound pressure transformation a part of the results achieved in these two types approach the results in Types 1 and 3. In Type 4 no audiological changes have been made in the oval window. Type 5 is practically identical with a fenestration operation for otosclerosis. The good results in these types with regard to the difference of the sound pressures between scala vestibuli and scala tympani can, therefore, be explained only by the assumption, that the closure of the very small middle ear, which consists of the lower ventilation channel only, has produced a very intensive sound protection for the round window. Nevertheless I change partly Type 4 to a Type 3, with an artificial (plastic) columella, which

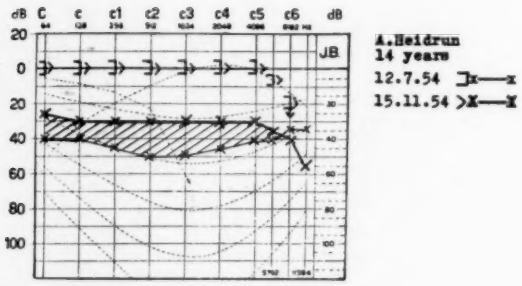

Fig. 11.—14.7.54 Tympanoplasty type V. 1. stage. Sclerosis of middle ear, oval niche closed. 30.10.54 Fenestration. 2. stage. 15.11.54 New tympanic membrane mobile.

rests like a wedge on the stapedial footplate between facial ridge and promontory. The indication for this procedure depends on the condition of the oval niche. If the latter is covered by an atrophic and adherent tympanic membrane or by a cholesteatoma matrix, I prefer Type 4 with a niche which is open towards the auditory meatus. On the other hand, if the niche is filled with granulations and the mucosa is almost completely missing, the periostitis and the superficial osteitis will again and again produce granulations. The final result will be an occlusion of the niche by scar tissue. In these pathologically very unfavorable situations, the artificial columella keeps the oval niche open for the sound transmission to the base.

This procedure demonstrates the importance of the condition of the mucous membrane for a tympanoplasty. A healthy and thin mucous membrane gives a good chance for its regeneration on the points of defect and for a good audiological result of the operation. But if there is a very marked thickening and infection of the mucous membrane, if the middle ear and possibly the tube secrete pus and if the window niches are full of granulations, very often one will not succeed in getting the ear dry and restoring the mucous membrane to normal by preoperative treatments, not even by change in climate, antibiotics, deep x-ray therapy of all cavities of the tympanum or intratubal radiation with radium. We must then decide whether to carry out the tympanoplasty in one stage or two stages. I am in

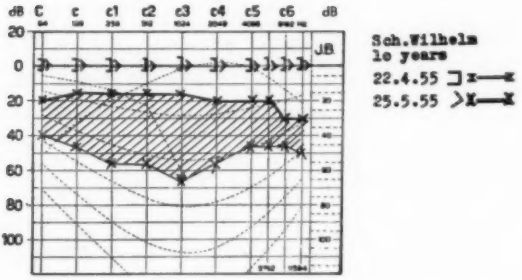

Fig. 12.—Tympanoplasty type IV. Radical mastoid operation years ago. Cavity still suppurating. Round niche filled with granulations, dissected, defect of crura stapedis. Skin-graft split over oval window. 25.5.55 New tympanic membrane mobile.

almost every case in favor of the one stage operation for the following reasons:

In the two-stage tympanoplasty it is not possible to be as conservative as necessary and to preserve the whole epitympanum, means to build Types 1 and 2, because after careful preparation of the whole structures of the middle ear, the narrow spaces between bridge, ossicles and windows will be filled again with connective tissue in the interval between the first and second operation.

If we want to operate in two stages, then we must always perform a radical operation with removal of the bridge, as Zöllner is doing. I carefully dissect the mucous membrane everywhere, and also open up all hypotympanic cells so that no pyoceles are left. The mucous membrane in the tubal corner and the round niche must be preserved particularly carefully. If the mucous membrane is very thickened, I scarify it with a fine knife and suck the edema out. Under the pressure of a resorbable antibiotic packing, which fills out the middle ear, it will then heal. In the round window niche the swollen mucous membrane must be prepared up to the membrane itself. If this can be done the prognosis for the round window is still favorable.

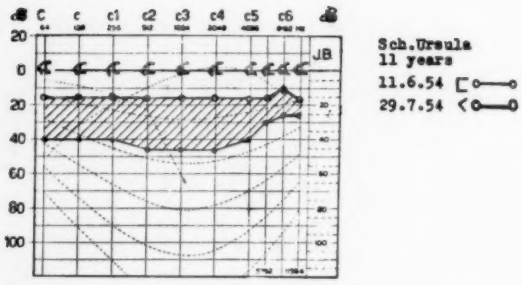

Fig. 13.—15.6.54 Tympanoplasty type III with plastic-columella. Cholesteatoma, large marginal perforation, defect of long process of the incus and of both crura stapedis. Middle ear filled with strong granulations. Plastic-columella, implantation of amnion, skin-graft. 29.7.54 New tympanic membrane mobile.

If there is no mucous membrane left in the round window niche, and if the niche is filled with dense or loose granulations and with adhesions, then it cannot be kept open in this way, not even with implantation of a substitute for the mucosa, because the tamponade of this implant must be done directly against the round window membrane. In my experience, the outer wall of the round window niche on the promontory must be taken down far enough with a fine diamond burr so that the adhesions can be removed right from the round membrane itself, and that the mucosal implant has direct contact with the membrane. In the presence of heavy granulations or extensive adhesions there will be large defects of mucous membrane on the promontory, on the promontorial and facial surface of the oval niche, in the sinus tympani and in the tubal corner. Then very extensive implants become necessary. Often amnion is sufficient to act as "biological dressing" (Sanvenero Roselli) because as heterotransplant it will be resorbed but replaced from the epithelium covering the adjacent areas of the mucous membrane in the hypotympanum. For such large defects conjunctiva will hardly be sufficient; it has, furthermore, many elastic fibers and, therefore, shrinks to a considerable extent.

Healthy antral mucosa can be of great help. In the most difficult cases a mucosal autotransplant will be needed, as poor in mucous

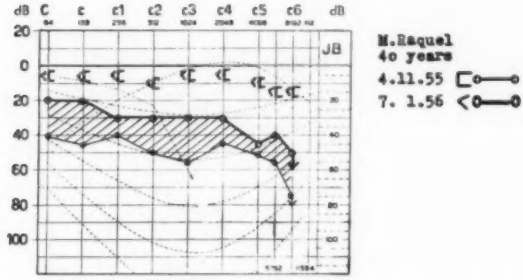

Fig. 14.—Adhesive process. 8.11.55 Tympanoplasty type IV, implantation of mucous membrane of lip (one-stage). Defect of stapes. Incus and malleus removed. Tympanic membrane completely adherent, detached, round niche closed by fibrotic masses, planed, mucous membrane of lip covering promontory implanted. Free skin-graft (overlapping the rest of atrophic drum membrane, freed from epidermis) split over oval niche.

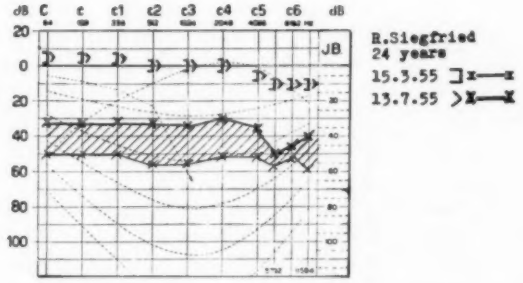

Fig. 15.—31.3.55 Tympanoplasty type IV. Large marginal perforation, small cholesteatoma in the attic, bony bridge and defect chain removed, oval niche covered with epidermis, footplate mobile, round niche closed by adhesions, planed, tube closed by bone, re-opened with diamond. Implantation of amnion in the tubal orifice, in the tympanum proper and on the round window. Free skin-graft. 13.7.55 Tube passage open.

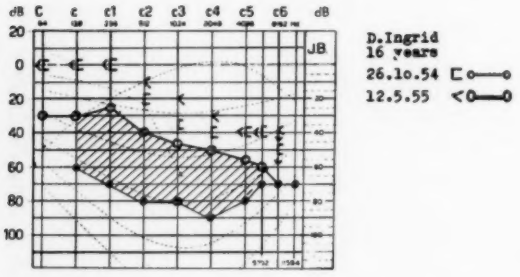

Fig. 16.—19.2.55 Tympanoplasty type II. Fenestra nov-rotunda. Central perforation, "lower control" of the middle ear: both niches closed by fibrotic masses. Incus and stapes freed, no indication of the round niche, large fenestra before subiculum promontorii, endosteum preserved, covered with amnion, free skin-graft overlapping the tympanic membrane. 12.5.55 New tympanic membrane mobile.

glands as possible, for instance, from the lower lip. This mucous membrane is, however, relatively thick. If the necessity arises I sometimes operate in two stages separated from each other by short intervals; the mucosa is implanted and left in the middle ear for acclimatization for a period of about three weeks. Then the tympanoplasty is completed before the implanted mucosa becomes chronically infected. Lately, I even have been able to reopen, with a diamond burr, the tube which had been closed by bone and to restore its function with the help of implants. For the implants into the tube mucosa cannot be used, but only amnion.

Tympanoplasty and stapes mobilization have shown that the stapes is only able to function if on palpation it is easily movable. True adhesive processes in the ligamentum annulare can be mobilized, particularly small bony bridges on the footplate. An ossified stapedial tendon can be cut. Extensive fibrous and osteitic fixations should, however, not be dissected although it might be technically possible. If the tympanic membrane and the ossicula are well preserved, but the malleus and incus are firmly fixed in the epitympanum, I cut the neck of the malleus and the long process of the incus and in this way I remobilize the tympanic membrane. If in a middle ear sclerosis (as it was named by v. Tröltsch) the whole oval niche is filled with fibrous masses, the stapedial footplate underneath is often movable.

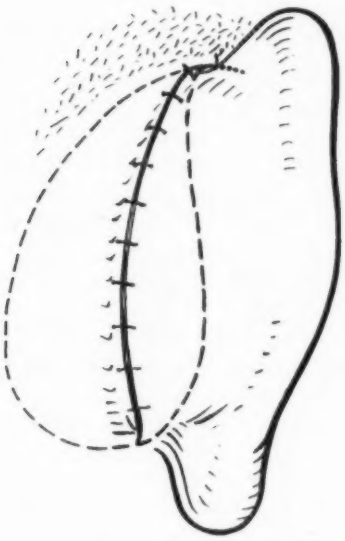

Fig. 17

It is not advisable to take the trouble to prepare it free, because the niche and also the epitympanum is, after such an operative remobilization of the ossicular chain, completely devoid of mucosa and there is great danger of formation of new adhesions. In such a case a tympanoplasty of Type 5, with fenestration of the lateral semicircular canal is preferable. Unfortunately, no easy substitute can be found for the fenestra in the scala tympani. Sometimes the entrance into the round window niche is closed by osteophytes. Then in most cases, one finds underneath a cyst lined with mucosa. The rare ossification of the round membrane itself is in most instances incomplete. A round window can be opened and closed again with amnion without danger to the cochlea. The result is, however, unsatisfactory because the proper relationship in the elasticity between ligamentum annulare and round window membrane, which is present in the normal ear, according to the investigation of v. Békésy, cannot be restored. Instead of this I have obtained a satisfactory result in a bony closure of the round window with a fenestra nov-rotunda. I exposed the endos-

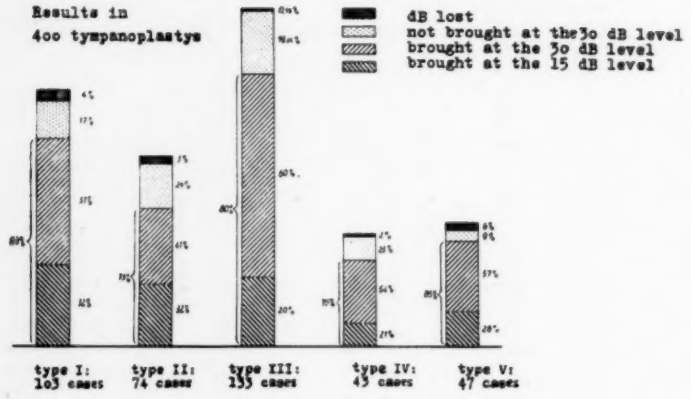

Fig. 18

teum of the scala tympani between the round window and the subiculum promontorii and covered it with amnion so that a coalescence between transplant and endosteum was established.

As a substitute for the defective tympanic membrane I have introduced free skin transplants; this was accepted later on by Zöllner, Moritz and others. I have furthermore shown that after circumcision of a perforation in the drum, the margin of the tympanic membrane in most instances unites without difficulty with the margin of the transplant. But to avoid later relaxations because of the abrupt change in the texture of the materials, I allow the transplant to overlap the tympanic membrane. The significance of the system of collagenous fibers in the drum has been re-emphasized especially by H. G. Kobrak. For this reason, every functional rest of the pars tensa is carefully preserved. The epidermis is incised with a very fine sickle-knife along the annulus tympanicus and detached from the periphery towards the perforation, so that the defect will not be enlarged. In places where the perforation is marginal the bone of the external meatus must be exposed for a distance of about 3 mm; then the transplant must be laid over the annulus fibrosus and over the meatal wall, particularly in the tubal corner. The annulus fibrosus must be carefully preserved because of its blood vessels.

Every little fold must be divided, because it would mean an interference with the nutrition of the transplant. We know through the work of H. G. Kobrak and v. Békésy that the tympanic membrane is stiff in itself and that it vibrates around its lower fold. In order to re-establish a good sound pressure transformer the surface which is exposed to the sound pressure must regain its firmness. It should, however not become too stiff through scarring, so that the effect of the sound pressure transformer would be reduced, but it must regain at least in a segment the ability to vibrate. In Types 4 and 5, the tympanic membrane carries out only one of its two physiological functions. For that reason the sound protector over the small middle ear cavity can be permitted to become very scarred and firm.

The skin transplant must close up completely all cavities of the middle ear in one piece. Thiersch-grafts are not strong enough. Full-thickness skin grafts heal better provided they are as thin as possible (see Harberts, Harris and Meadows). I take these skin grafts always from behind the ear to an equal extent from the concha and from the planum mastoideum. This skin contains no hairs and like the scalp few elastic fibers only and therefore does not shrink and curl. The scar in the postauricular fold will be invisible. Since the cartilage of the ear is not incised the concha will regain its original position within a short time.

This and a second reason have led me to the retro-auricular approach: In every audiosurgical operation it might nowadays become necessary to inspect the round window niche up to the membrane itself; this is always the case in tympanoplasty. The membrane is situated in the anterosuperior part of the niche, and this area can only be visualized from behind and below. From the "lower control point" of the middle ear it is well possible to observe under the microscope, by slightly touching the stapes, the more pronounced vibrations of the round membrane.

Pediculated cutaneous flaps over the middle ear are not nourished through the pedicle. The critical days for necrosis at the free margins of the flap are those at the end of the second week. Marginal necrosis can only be overcome through colliquation.

After the first bandage has been taken off after about one week, the auricular cavity should be kept as dry and free from infection

as possible, by daily cleaning and open treatment. Recurrent perforations I am seeing now in less than 10 per cent of the cases. They are mostly small marginal perforations which can easily be closed through a second operation.

The restoration of an air-filled and ventilated middle ear with movable tympanic membrane is achieved not through the skin graft alone but with the additional help from a resorbable packing within the reconstructed middle ear cavity which preserves the lumen during the process of healing. All such substances must be tested in animal experiments, to make sure that they will be absorbed without reactions within two weeks.

Thin and viscid fluids flow out of the window niches and the tubal corner, where they help in the tamponade of the implants. For this reason I am using small pieces of sponge to fill up the middle ear. Pure gelatine soaked with penicillin and hyaluronidase has been very effective from the very beginning. Only in extensive defects of the mucous membrane and in severe inflammations of the middle ear there is a danger of adhesions. If in such cases, at the beginning of the third week, the ventilation of the tube under controlled pressure and under visual observation fails to demonstrate patency, puncture of the middle ear with a fine needle becomes necessary with one or two injections of hyaluronidase through the hypotympanum into the tube. The necessity of general antibiotic therapy is self-evident. Besides, at this time a therapy with cortisone can be very helpful. The hearing improvement manifests itself with this technique mostly within a few weeks, but sometimes continues for several months.

For the Types 4 and 5 (sound protection with an open oval window or a newly created labyrinthine window) the results are theoretically the same as after a fenestration operation for otosclerosis. In practice this goal is reached in a very high percentage of cases, and under favorable circumstances of sound protection even surpasses. In the Types 1 to 3 we theoretically reconstruct the sound pressure transformer. A result of 30 db can, therefore only be regarded as sufficient but not as good. The restoration of an ideal sound pressure transformer, the elimination of the conductive loss up to 5 db will, however, be reached only in a very small percentage of the cases, especially in those of the Type 1. I therefore regard in these types all those results as good where the conductive loss for

500 to 2000 cycles is smaller than 15 db. The results of 400 tympanoplasties which were performed up to one year ago show that this goal is reached in about one-third of all cases; this percentage must and can still be improved through a better technique especially if one prevents relaxation of the drum and formation of adhesions in the middle ear. In contradistinction to the fenestration operation for otosclerosis the tympanoplasty completely cures the disease of the middle ear which causes the hearing loss.

For the many problems which present themselves in the restorative surgery of the middle ear, I could pick out only a few and these are merely of an operative technical nature; I was unable to deal here in greater detail with audiological-theoretical questions but I hope to discuss them more thoroughly in a few days. The change in the concepts of the treatment of chronic otitis media had to touch on many problems of the physiology and pathology of the middle ear and also of the microsurgery of otosclerosis and of malformations of the external auditory meatus. Lack of time did not permit a thorough appreciation of the efforts of the many authors who have worked on these problems; an enclosed index of literature on this theme will quote them in detail.

WURZBURG, GERMANY

LXXXIX

AN INTRODUCTION TO A SYMPOSIUM ON THE UTRICLE

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The vestibular portion of the internal ear, or labyrinth, has been recognized as part of the postural mechanism of the body during the last hundred years, but we have made little progress in determining the exact functions of some of its individual end organs. Breuer[5] stated that whereas the semicircular canals are stimulated by rotation or angular acceleration, the otoliths are stimulated by linear acceleration and by change of position of the head in space in relation to gravity. He gave to the otoliths the name of "static sense organs." This differentiation has been confirmed by Magnus and de Kleyn, Versteegh, Ulrich, Tait and McNally, and Ross among others.[31] When studying an end organ such as the utricle one is interested in two aspects. John Tait[36] pointed out that its propriation should be known—how does it act—and secondly, its servation should be understood—what is its function. In order to understand its propriation we must have some idea about its detailed anatomy, about its connection with the central nervous system and with other parts of the body. The structure of the utricle consists of an area of neuroepithelium called the macula which, through its nerve supply, is connected to the central nervous system. Overlying the macula is the otolith or otolithic membrane. The macula, which lies in a horizontal plane, is particularly inaccessible to eperimentation in most animals because of its intimate relationship to the ampullary end organs of the horizontal and anterior vertical semicircular canals.

Since the advent of the electron microscope the finer structure and circulation of the end organs of the labyrinth, both semicircular canals and otoliths, as well as the perilymph and endolymph, are

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Note related papers, pp. 450 and 470, Annals for June 1956.

under study and it is hoped that valuable additional information will be forthcoming.[13,35,43,44]

FUNCTION OF THE UTRICLE

The utricle is one of two otoliths in man, the other being the saccule. The saccular otolith, as far as can be determined, does not have any proven vestibular or balance function.

The exact mode of action of the utricle (its propriation) has never been settled. Magnus[28] made a great contribution when he analyzed and separated postural reflexes. He classified labyrinthine positional reflexes into:

1) Attitudinal reflexes, resulting from tonic labyrinthine reflexes on the body musculature, on the limbs and on the neck.

2) Compensatory eye positions, both vertical and rotatory.

3) Labyrinthine righting reflexes, asymmetrical and symmetrical.

Attitudinal reflexes are not entirely labyrinthine in that they arise from a collaboration or co-operation of the tonic labyrinthine reflexes with the neck reflexes. Versteegh's[41] experiments indicated that all the positional labyrinthine reflexes arise from the utricle. He succeeded in sectioning the nerve to the utricle on one side in a rabbit. Following this operation all the known reflexes which had been ascribed by Magnus and de Kleyn to both the saccule and the utricle could no longer be elicited. Versteegh was careful to note that there was no spontaneous nystagmus following uncomplicated severance of the utricular nerve in the rabbit.

Ulrich[40] reported experiments which he carried out upon the utricle of the live pike. He stimulated the uricle by means of a fine hair. His experiments were exceptionally well controlled so that the stimulation was, in so far as possible, restricted to the utricle and its otolith. If there was spread of the stimulus, it was usually recognized and was given due consideration in the estimation of the results. He found that movements of the otolith forward or to its outer side elicited eye reactions which are in keeping with the reactions

to tipping tests. Pressure on the utricular otolith elicited the ordinary compensatory eye movements which result from tipping an animal forward or to the homolateral side. Ulrich observed that moving the otolith to the midline did not cause any reaction. He reported that moving the otlith backward was not free from technical difficulties. It is important to note that he reported that there was no nystagmus following uncomplicated utricular stimulation.

Tait and McNally[38] reported a technique for severing the nerve to the frog's utricle on one or both sides without injury to other parts of the labyrinth. They could also sever the nerves to the semicircular canals and other otoliths, leaving only the utricles intact. From these experiments they confirmed the findings of Versteegh that the utricle gives origin to the labyrinthine righting reflexes and tonic reflexes on the neck, body and limb musculature. They found that the utricle does not respond to angular acceleration about a vertical axis but that it does respond to centrifugal force and is responsible for the animal's protective lean toward the centre of rotation. The utricle also responds to linear acceleration. The utricle is stimulated by a slow tilt and when so stimulated it elicits a compensatory reaction of the body and limb musculature which tends to keep the head level. They also found that the utricles in a frog are stimulated by a quick tilt (angular acceleration) about a horizontal axis, but in the absence of all six semicircular canals the response is anticompensatory. It is in the wrong direction to protect the animal and is in the opposite direction to the reactions which normally follow semicircular canal stimulation. It was suggested that this reaction of the utricles to quick tilting may be a mechanism to control a tendency to over-action of the semicircular canals. Co-operating together, the vertical canals and utricles tend to bring about the necessary amount of compensatory reaction when the labyrinth is acting as a whole.

ELECTRICAL RECORDINGS FROM LABYRINTH

Ross could not confirm the reaction to a quick tilt about a horizontal axis in the frog's utricle preparation from which he was recording electrical reactions. The electrical activities from single nerve fibres from the labyrinth have been recorded by a number of observers, Ross[34] in the frog, by Löwenstein[27] in the dogfish, and by Coppee and Ledoux[7] in the frog. All reported that the utricle responds to gravitational stimuli. Ross did not find a resting response, whereas Löwenstein, Coppee and Ledoux reported the presence of resting dis-

charge. Ross and Löwenstein both stated that the utricle responded to linear acceleration. Löwenstein, and Coppee and Ledoux reported that the utricle responded to vibration as well as did the saccule.

LABYRINTHINE TONE

Ewald was the first to describe labyrinthine tonic influences and he pointed out that there are two distinct types acting upon the muscles. He reported that a pigeon, after a bilateral labyrinthectomy, and with its eyes covered with a hood, showed two types of tonic disability: 1) it lacked the capacity for acting quickly; 2) its head tended to be displaced when subjected to a steady pull or pressure. The displacement of the head was followed by changes in limb posture. Tait pointed out that this change in limb posture was brought about by the neck reflexes described by Magnus and de Kleyn. The loss of quick action had been shown by Tait and McNally to be in large part due to absence of the semicircular canal reflexes. Tait and McNally had shown that in the frog, when a semicircular canal was stimulated, the muscle response required (35 sigma) 1/30 of a second to bring about a protective reaction. The stretch reflexes of the muscle and the tendon reflexes described by Liddell and Sherrington[25] are in themselves unable to protect an animal without labyrinths in a sudden emergency such as landing after a jump. They are only local reflexes. It requires the rapid message to the whole body musculature to prepare the animal for a sudden musculature emergency. Tait and McNally were able to show that the utricular macula emits nerve impulses during head movements only and that the macula remains quiescent so long as the head is stationary. If a frog is slowly tilted through an increasingly greater and greater angle it makes, at intervals, new compensatory movements with its body musculature by which on each occasion the head is brought once more to, or nearly to, the horizontal. All the separate stationary postures involved can be artificially imposed upon and then held by a completely delabyrinthized frog, as shown by Beritoff.[4] There is no need to assume that the utricular macula exerts a continuous tonic influence or, in other words, is constantly engaged in signalling. The end organ emits nervous signals only at particular junctures, namely, when the head is moved. One questions whether there is a resting discharge from the utricle as reported by some authors referred to above who have recorded electrical discharges from the labyrinth. During any head movement the semicircular canals and the utricles dictate the

necessary musculature readjustment to return the head and eyes to their original level position in space and the new position is maintained by a holding mechanism of the muscles. The labyrinth, therefore, serves to dictate new positions necessary to compensate for movement but it does not maintain these positions during rest.

POSITIONAL NYSTAGMUS

We should make some reference to positional nystagmus because its original has been associated with utricular disease. Positional nystagmus refers to that nystagmus which occurs when the head is in a particular position and it is frequently associated with the complaint of positional vertigo. In order to demonstrate this nystagmus the patient should be examined in different positions, including the supine position with the head hanging over the end of the table. Nylén[3] in 1935 described two main types of positional nystagmus; one in which the direction of the nystagmus changes with alteration in the position of the head, and another in which the nystagmus may only occur in certain head positions. There is no uniformity of opinion as to whether one type is more indicative of a central nervous system lesion than is the other.[26,32] Dix and Hallpike[10] have used Nylén's second type of positional nystagmus as a distinguishing feature of a group of cases with vertigo in which the cochlear and vestibular functions were found to be normal but in which about half the cases had evidence of middle ear disease. They described a post mortem report of one patient in the above group in whom a glioma was found to have involved the basal ganglia and the upper part of the brain stem on the left side. There was also histological evidence of degeneration of the spiral ganglia in the cochlea on the right side. In the macula of the right utricle and the right saccule there was absence of the otolithic membranes, disorganization of the sensory cells and thickening of the subepithelial connective tissue, with irregular cellular infiltration. In spite of this widespread pathological finding, the authors concluded that the positional nystagmus in this patient had resulted from disease of the utricular macula. Oddly enough, though they do associate directional preponderance with utricular disease they do not report the presence of directional preponderance in this group of cases with positional nystagmus which they attribute to utricular disease. Because the utricle is associated with positional changes it has been charged with being the source of positional nystagmus. It should be recalled that the utricle is not

signalling when the head is held steady and in one position, but only when the head is being moved.

INTRACRANIAL CONNECTIONS

The intracranial connections of the labyrinth have been under study for some years but the detailed interconnections of the vestibular system are still in a nebulous sate. It is generally known that the nerve from the labyrinth goes to vestibular nuclei and that from there it has a widespread connection with the cerebellum, with the cerebrum, and with the body musculature. The connections with the external ocular nuclei are particularly well known. It is also known that there are connections with the autonomic nervous system. During the past few years efforts have been made to determine more accurately the cortical representation of the vestibule. Speigel[36] was one of the first in 1934 who reported the cortical representation of the vestibule in the cat. Kornmuller[24] and Gerebtzoff[15,16] published important papers. Penfield and Rasmussen[33] reported on the general problem of cortical localization in man. In 1953 Elizabeth Crosby[9] discussed the importance of nystagmus as a sign of central nervous system involvement. Cranmer,[8] Walzl and Mountcastle,[42] Mickle and Ades,[29] and Andersson and Gernandt[2] have made contributions concerning the cortical projections of the vestibular nerve in the cat. The findings might be summarized by quoting from Walzl to the effect that positive monophasic potential changes were evoked in circumscribed cerebral cortical areas of the cat following vestibular stimulation. The effect is chiefly contralateral; the cortical area is above and anterior to the anterior descending limb of the suprasylvian sulcus and includes its anterior bank. It borders the auditory areas posteriorly, the first somatic areas anteriorly and the second somatic areas ventrally. Many of these authors have concluded that the cochlear and vestibular areas in the cortex show marked overlapping.

TESTS OF UTRICULAR FUNCTION

There are no generally accepted tests for utricular function in clinical practice. This is because of the scarcity of detailed and exact knowledge about the utricle. Tilting tests have been described[18] and Tait and McNally[30] but have never received generalized adoption. Graybiel, Niven and Walsh[19] in 1952 described experiments in which they submitted human beings to stimulation on a large centrifuge. They were able to use differential stimulation, i.e., angular acceleration

on the one hand, which stimulated the semicircular canals, and centrifugal force stimulus on the other hand, which stimulated the utricles. It is noteworthy that when pure centrifugal force was the stimulus affecting only the utricles there was no nystagmus.

DIRECTIONAL PREPONDERANCE

Directional preponderance is a phenomenon which has by some authors been associated with disease in the utricle and for that reason will be briefly mentioned. It refers to a phenomenon which may be described as a tendency for nystagmus of the eyes to occur more readily to one side than to the other. This phenomenon was first described by Dusser de Barenne and de Kleyn[11] in 1923, when they reported that if a cerebral hemisphere was extensively damaged post-rotational nystagmus directed to the side of the lesion, which they called a "nystagmu bereitschaft," was longer lasting than the nystagmus to the opposite side. This confirmed an earlier experimental observation of Bauer and Leidler[3] in 1911. In 1942, Fitzgerald and Hallpike[14] reported that the lesion causing the phenomenon was situated in the temporal lobe. Cawthorne, Fitzgerald and Hallpike[6] in 1942 described a method of alternate hot and cold caloric stimulation of the labyrinth which is well suited to bring out this phenomenon which they called "directional preponderance." In a more recent article Hallpike[20] reported the presence of directional preponderance to the opposite side in Ménière's disease in 21 per cent of the patients. He finds it present in a condition which he calls "vestibular neuronitis" in eight per cent of cases. This group of patients is characterized by having dizziness but with normal hearing and abnormal vestibular reactions. He says that it is present in early cases of eighth nerve tumor, and in lesions of the temporal lobe. In this same article he states that a lesion of the utricle is responsible for a directional preponderance to the sound side in cases of unilateral labyrinthine disease because a directional preponderance quite often occurs without any evidence of a semicircular canal lesion. Jongkees[21] in 1948 reported directional preponderance in 20 per cent of a series of normal individuals. Andersen et al[1] in 1954 did not find directional preponderance present in a series of normal individuals but did report it in supratentorial lesions not involving the temporal lobe. Kirstein and Preber[23] in 1954 stated that directional preponderance in cases of cerebral lesions has no localizing value. They stated that it was found in lesions of the frontal, parietal and occipital lobe in which there was

no obvious lesion of the temporal lobe. Thomsen discusses the difficulty of establishing a time beyond which the reaction must be considered abnormal.

SUMMARY

John Tait has summarized the effect of utricular stimulation by stating "if, by slow tipping of the substratum, by linear acceleration of the substratum in a horizontal direction or by centrifugal force, the effective direction of gravity is for the time being no longer normal to the plane of the substratum then the animal in virtue of its possession of utricular maculae makes a compensatory movement. By this is meant a movement in which the head and the body are displaced in such a way that the centre of gravity of the body falls better within the base of support." In other words, the utricle is stimulated by any change of head position which alters its relation to gravity. It responds to turning which involves the centrifugal force and to motion in a straight line—linear acceleration in either a vertical or horizontal plane. It works in close co-operation with the semicircular canals. The utricle has been shown to exert a dominant influence over labyrinthine tonic reflexes, labyrinthine righting reflexes and labyrinthine compensatory eye deviations. The best controlled experiments in which stimulation or ablation was strictly confined to the utricle have not elicited eye nystagmus.

The propriation of the utricle is not known, that is, how it acts and performs its function. Details of its intracranial connections, and particularly of its cortical representation are lacking. In recent clinical literature the utricle has been connected with the production of eye nystagmus, with directional preponderance of nystagmus and with positional nystagmus. The association is for the most part based on clinical speculations unsupported by experimental evidence.

It is hoped that as a result of this symposium we will have a clearer and more exact knowledge of what we do know about the utricle and of what is still to be learned.

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XC

SOME RECENT EXPERIMENTS ON THE NEUROPHYSIOLOGY OF HEARING

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Since it would be impossible for me to discuss all the recent experiments on the neurophysiology of hearing I shall restrict myself to only two of those with which my colleagues, Drs. Guy Sheatz and Vernon Vernier, and Mr. Allen Rupert, and I have recently been concerned. The problem underlying these experiments is not one of those traditional subjects of hearing investigations—pitch, loudness and localization; instead we have been attempting to study the neurological mechanisms by which an individual focuses attention upon some sounds while totally disregarding others. Otologists often illustrate this problem with the story of the young mother who sleeps soundly while elevated trains rush noisily past her window, but wakens promptly at the slightest whimper of her sick child. What is the nature of the neurological machinery by which she hears what she wishes to hear and pays no attention to other sounds? Can we devise ways to study this attention phenomenon common to the auditory experience of most people, and presumably of animals as well?

The first step in our attempt at an experimental analysis was to cause animals to attend to sounds when we wished them to do so, and to be indifferent to those sounds when this served our purposes. Cats were trained to "listen" to clicks by giving them shocks every once in a while as the clicks were presented. The animals did not like the shocks, and since these occurred only with the clicks, they associated the sounds with the unpleasant experience and acted, so far as we could determine, as if the clicks were a listened-for signal of the painful event. To render the animals indifferent to the sounds we

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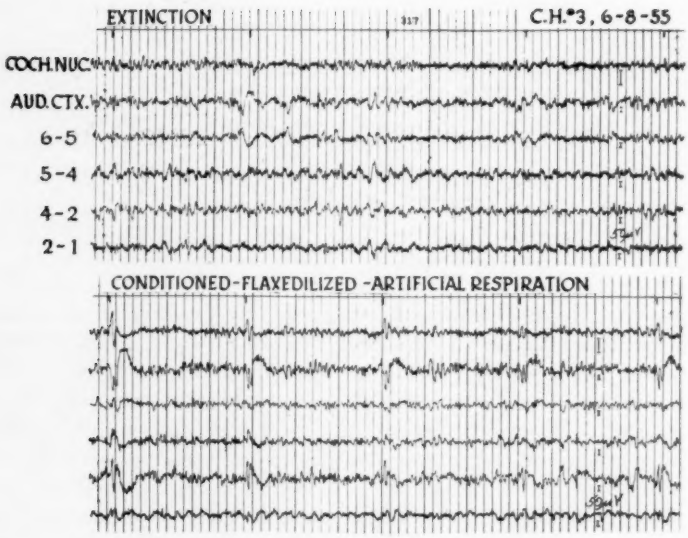

Fig. 1.—EEG traces taken from electrodes implanted in a cat.

simply left the clicks turned on day and night, without shocks, until the animals acted as if they were paying no attention to them.

Meanwhile the electrical responses present in their brains were under constant scrutiny through wire electrodes previously implanted in the various auditory nuclei. The method of implanting wires at sterile operation and studying the brain responses for weeks and months thereafter is absolutely required for experiments of the sort I am describing, for only alert, awake animals can serve as subjects. I suspect that if any one thing is certain about an animal under anesthesia it is that he cannot attend to stimuli, auditory or otherwise.

Let us look now at the EEG tracing from one of our subjects (Fig. 1). The top line shows a mark when a click was presented. The remaining lines are derived from various places in the hippocampus. The upper seven traces show the clicks evoking small responses from the brain; this animal had been living with the clicks

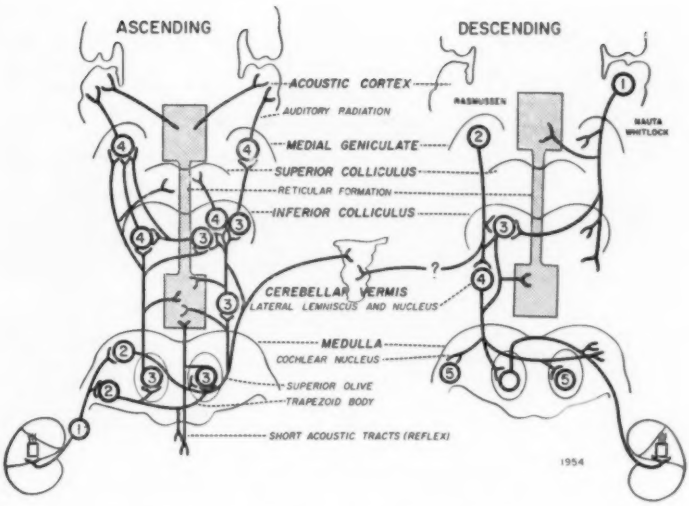

Fig. 2.—Anatomical plan of auditory neurons.

for many hours and gave every sign of being completely indifferent to them. In the lower seven traces, however, the responses evoked by the clicks are considerably larger corresponding to the fact that the animal had meanwhile been conditioned to expect shocks every once in a while with the clicks and, presumably, was "listening" for them. It will be noted that the cat, in addition, was paralyzed with flaxedil and was receiving artificial respiration; it had been subjected to this additional indignity to make certain that no artifact from muscle movement could contaminate the records. The experiment shown here, it may be added, was repeated with variations eight times on this animal and numerous times on others also. It is only fair to add however that we cannot reproduce these results in all animals, a fact we interpret as indicating we do not yet understand as well as we should what the important variables in such an experiment actually are.

Nevertheless, from experiments like that shown in Figure 1 we feel three important conclusions can be drawn. First, the combination

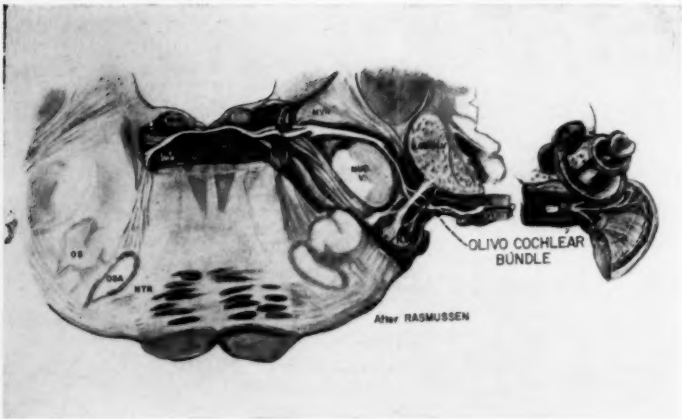

Fig. 3.—Anatomy of olivocochlear pathway in cat.

of modern techniques of psychology and neurophysiology makes possible a direct attack upon certain of the so-called higher functions of the brain of animals, in this case, attention to sounds. Second, the studies on cats show that the attentive animal displays more activity in a larger number of brain locations than does the inattentive one. Finally, the responses vary in size not only at the auditory cortex, which most of us expected to be true, but at all the lower nuclei, including the cochlear nucleus, as well.

This last finding implies some regulating mechanism by which impulses are delivered to the auditory nuclei to control the amount of activity that occurs there. If the magnitude of the evoked response rises and falls with attention, and if this happens more or less simultaneously throughout the auditory brain, it is only reasonable to postulate some single neural system responsible for the regulation.

Figure 2, which is a summary of our present knowledge of the anatomy of the auditory system, will be of assistance in exploring the possibilities for such a regulating system. On the left are shown the pathways by which auditory neurons convey impulses from the cochlea to the cortex. In addition to the classical textbook route

via cochlear nuclei, superior olives, inferior colliculus and medial geniculate, a recently discovered alternate by way of the reticular formation exists. It may be noted also that a pathway to the cerebellar vermis has been described, though its functional significance has not.

Our chief interest however is not in the ascending fiber paths but rather in the descending ones shown on the right of the diagram. Notice that a system of neurons originating in the cortex descends in the brain, terminates in each of the nuclei of the classical ascending auditory pathway, and finally ends up in the cochlea itself. Almost nothing is known of the function of this descending system. I mention it to you only because in my speculations I have wondered whether it might be concerned with those changes in response-size to be seen in cats when they attend to sounds.

Actually something more than speculation can be presented to you in the discussion of this descending system. I have some experiments to report, experiments performed upon that segment of the system originating in the accessory superior olivary nucleus and terminating inside the cochlea. This so-called olivocochlear bundle, which has been intensively studied by Dr. G. L. Rasmussen, is shown in detail in Figure 3. Notice that the cells of its origin lie in the region of the superior olive; the fibers then ascend to the roof of the medulla, decussate, intertwine with fibers of the facial nerve, pass over the nucleus of the fifth nerve and make their way out with the auditory. In the cochlea these efferent fibers are all contained in what you know as the bundle of Oort—in fact, this bundle is entirely made up of outgoing fibers. Within the cochlea the fibers distribute themselves in the internal spiral bundle to the entire length of that organ, and they eventually terminate near (if not actually upon) the internal hair cells.

Our experiments with this bundle of fibers began with the following question: what happens to the inflow of nerve impulses aroused by any auditory stimulus if one produces, at the same time, a stream of impulses passing outward in the efferent fibers? The actual experiment, performed with the conventional anesthetized cat, involved examing the response to a click as this is recorded at the round window both with and without simultaneous electrical stimulation of the olivocochlear pathway at its decussation in the medulla.

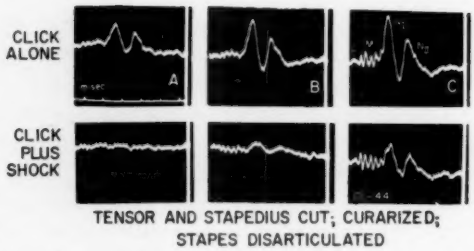

Fig. 4.—Round window responses to click modified by shocks to olivocochlear pathway. Top row: normal responses to three click intensities; bottom row: the auditory nerve component is abolished when olivocochlear bundle is activated by shocks.

Figure 4 shows the results of such an experiment. The typical round window response is labeled in the top row; the activity of the cochlear hair cells is labelled M, and N_1 indicates the discharge of the auditory nerve to the click. N_1 grows progressively larger as one moves from left to right in the top row corresponding to an increase in the strength of the clicks.

Immediately below each response in the upper row is the response to an identical click aroused, however, while the olivocochlear bundle was being activated by shocks delivered at 100/sec to the roof of the medulla. Notice that the size of N_1 is in every case reduced in the bottom row, while little if any change is to be seen in the hair cell response, M. This demonstration that activity in the olivocochlear bundle diminishes the auditory nerve response expected to result from an acoustic stimulus defines its only known function. It is a suppressor, or inhibitor, and it exerts its action somewhere near the junction of the hair cells and auditory nerve in the cochlea.

We unfortunately do not as yet know whether the olivocochlear bundle performs its inhibitory function in the unanesthetized animal, but this is a matter which is clearly open to experimental study. If it did do so the descending auditory pathway, of which it is the last link, would be even more strongly implicated as an important component of the mechanism regulating the central neural consequences of a given auditory stimulus. As we have seen in the cats with im-

planted electrodes, the brain is not equally activated by identical stimuli; the changes evoked are large or small depending on the state of the organism we have called attention. The olivocochlear experiments similarly demonstrate that responses in the auditory nerve may be large or small depending upon activity present in a specific part of the central nervous system. It seems likely to me that these two observations are closely related, and we propose to continue our research for whether and how they may be.

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XCI

OBSERVATIONS ON THE DEVELOPMENT, STRUCTURE AND COMPOSITION OF THE COCHLEA OF THE RAT

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The intriguing, well hidden organ of Corti still holds many secrets; also, much of the laboriously gathered information about this structure is controversial. In recent years, new methods of observation such as the electron microscope,[1,2] the phase contrast microscope[3] and the techniques of histochemistry[4-7] have given renewed vigor to the investigators.

During the past ten years in this laboratory, we have incidentally observed the inner ear in heads of rats and hamsters of various ages, which were prepared for autoradiographic studies of the growth and mineralization of bones and teeth. Our attention was particularily attracted to the structure when an autoradiograph showed radioactivity at the level of the otoconiae of the macula after an injection of $Ca^{45}Cl_2$. A comparable picture was observed when mineralized sections were exposed to the radioactive calcium chloride in vitro,[8] pointing to atomic interexchange. A search of our previous experimental material, labelled with P^{32} (phosphoric acid), did not reveal any image over the inner ear. These findings were in accord with already recognized differences between the salt of the otoconiae and that of the bones and teeth.

Subsequent tracer work with S^{35} labelled sulfate[9] and methionine[10] has revealed that a sulfated organic fraction could be recorded over the inner ear membranes while the tectorial membrane specifically, did not reveal the presence of protein synthetized from the sulfur-contain-

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ing amino acids, in contrast to the epidermis, hair and enamel of the teeth.[11]

The present study was motivated by the desire of comparing the above-mentioned results with data obtained through the utilization of procedures which reveal differences amongst the polysaccharides retained in the course of standard histological processing.

MATERIALS AND TECHNIQUES

After removal of the brain and jaw, the heads of 12 young rats (Sprague-Dawley) with a range of 4 to 12 days of age (weight: 8-27 gms) were fixed for 48 hours in formaldehyde-ethanol (1/3), at pH 7.8, embedded in low-viscosity nitrocellulose, without demineralization, sectioned at 10-12 μ and mounted on glass slides for staining.[12] Since the inner ear in most of these specimens seemed not fully differentiated, the head of two weanling rats of 40 gms were placed in Bouin's picro-formol for three days.[13] They appeared then sufficiently demineralized for cutting with the celloidin microtome. The sections were all made parallel to the alignment of the molar teeth, cutting the cochlea radially, along the modiolus and across the coiled chambers. Routine staining with hematoxylin and eosin or hematoxylin-phloxine-orange G was carried out to obtain a standard. Other sections were stained by the periodic acid-leucofuchsin method of Hotchkiss-McManus[14] with or without an hematoxylin counterstain; some of these were pretreated for one hour at room temperature in 1 per cent malt diastase for removal of glycogen and starch. Some sections were stained in 0.5 per cent aqueous toluidine blue and examined in water or mineral oil for metachromasia. Some sections were incinerated at 600° C by the method of Policard-Scott.[15]

Finally, a few specimens were dehydrated in graded ethanol without staining and coverslipped with synthetic resin (Permount, Fischer) for examination in phase contrast (Bright and Dark M, A.O.).

OBSERVATIONS

Differentiation of the organ of Corti and periodic acid-Schiff staining. In the rat, as in man, the canal of the cochlea makes two and a half turns around the modiolus. In radial sections, sometimes two, sometimes three superimposed portions of the structure are observed; these will be termed: upper, middle and lower tiers in the following descriptions.

The cochlea, particularly the area of neuroepithelium is incompletely and unevenly differentiated in suckling rats. Four days after birth, the area represented by the internal spiral sulcus in the adult, is filled with long, cylindrical elements resting on the lamina spiralis and extending towards the membrana tectoria to which they are attached by numerous slender filamentous processes. The nucleus of these cells is clear and distally located. The cytoplasma above the nucleus is coarsely granular and the individual masses are moderately stained by the Hotchkiss-McManus technique (PAS). In the upper tier, these cells appear foamy, less granular, and their processes are longer. On the outside of these transitional elements, the inner sensory cell, the two pillar cells and the three outer sensory cells show individual characterization although they are all short, stubby and immature. The tunnel of Corti does not exist. One or two cells outside this area have acquired a pointed apex characteristic of the future Hensen cells. The immature sensory cells are only lightly colored by the PAS. The phalangeal cells are not differentiated. The basilar membrane is wide and apparently less compact than in the older animals. The vas spirale is large and prominent. The tectorial membrane extends from the top of the limbus outward over the transitional cells of the sulcus, and over the area of neuroepithelium as far as the first outer cell. It consists of a uniform apparently solid mass of material highly PAS positive.

In one specimen, the outer extremity of the membrane was in the form of fine filaments lying parallel to the sensory cells underneath and extending as far as the third outer cell.

In the lower tier, the area of neuroepithelium was less differentiated still. None of the specialized cells could be recognized with certainty. The membrana tectoria had the same appearance as above, and was flattened against the cells along its whole length. A comparable stage of development was observed in the cochlea of a hamster of the same age.

At ten days, the pillar cells had elongated in the upper tier and the inner tunnel was apparent. The inner and outer sensory cells were still stubby but taller. In the first outer cell, a mass of cytoplasmic material directly above the nucleus gave a moderate PAS reaction. The two proximal Hensen cells were also taller; their pointed apex was turned inwards. The internal spiral sulcus was beginning to hollow out by progressive transformation of the transitional cells

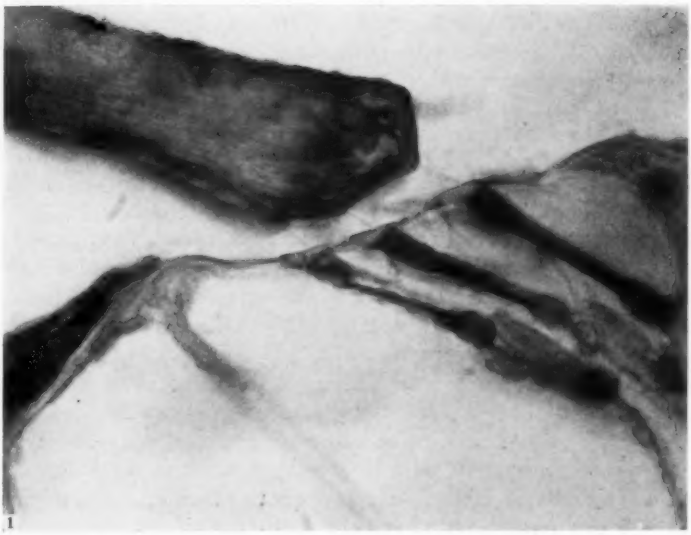

Fig. 1.—Radial section of the sensory portion of the organ of Corti from the upper tier of the cochlea of a 20 days old rat. Periodic acid-Schiff-hematoxylin, x2000.

starting in the inner portion, close to the limbus. The cells in that area seemed to lose their filaments and their tall, highly secretory appearance, and became separated from the tectorial membrane. The tectorial membrane was now thicker. A strong PAS reaction was still observed at the periphery, particularly at the lower border (Hensen's stripe). The central portion showed fine striations and reacted moderately and unevenly to the PAS. In all specimens of that age, fixed in formaldehyde-ethanol, the outer portion of the tectorial membrane was curled upwards.

The basilar membrane appeared to be more consistent now; the acoustic strings were prominent and highly positive to the PAS. The vas spirale was again large and prominent. A long, thin zone of connective tissue underlying the stria vascularis showed clumps of extra cellular material intensely positive to the PAS.

In the middle and lower tier, the internal spiral sulcus was still closed. The area of neuroepithelium was differentiating but morphologically much behind the same zone in the upper tier. The membrana tectoria was homogeneous and closely related to the cells underneath, reaching outwards as far as the third outer cell.

In the weanlings of 20 days, the organ of Corti seemed to have reached functional maturity, at least in the upper tier. In the middle and lower tiers (Fig. 3), there was still evidence of immaturity. The spiral sulcus was not entirely clear of cellular material, although the tectorial membrane was completely detached in that portion. The membrane at that level was homogeneous, highly positive to the PAS (Fig. 3). It rested over the outer pillar cells and its free extremity was sometimes curved upward (Fig. 3). In the Bouin-fixed tissues, the extremity of the tectorial membrane (Fig. 2) seemed to rest against the apex of the outer sensory cells. The ensemble of the membrane and the outer cells appeared at low power, to form a linear complex at an angle of approximately 45° to the basilar membrane. The sensory cells were all weakly positive to the PAS. The apex of the cells of Hensen have grown together into a compound process which has bridged over the outer tunnel reaching inwards towards the sensory cells (Fig. 3). The basilar membrane was prominent and heavily stained with the PAS.

The organ of Corti in the upper tier has revealed a marked specialization of the cells. The inner sensory cell was flask-shaped, showing a large, clear, ovoid nucleus located distally (Fig. 1). The cytoplasma in the stained preparations and also in the unstained phase contrast image, showed numerous fine, filaments oriented lengthwise. It stained lightly with the PAS (Figs. 4, 5). The hair at the apical extremity were clasped in a tight, pointed mass, tilted at an angle slightly different from that of the cell (Fig. 1). The distended heads of the long, slender pillar cells showed the concave-convex coupling already reported (Maximow and Bloom, 1952, Fig. 1). Both cells were remarkably negative to the PAS (Figs. 1, 4, 5).

The three outer cells appeared as long, even, rectangular formations of approximately equal size (Figs. 1, 4, 5, 6-d). Their distal portion was slightly displaced from the apparently normal resting position in the cup of the respective phalangeal cells (Figs. 1, 6-l). The nucleus was located close to the distal border of the cell; it was round and clear; it contained a prominent nucleolus. Immediately

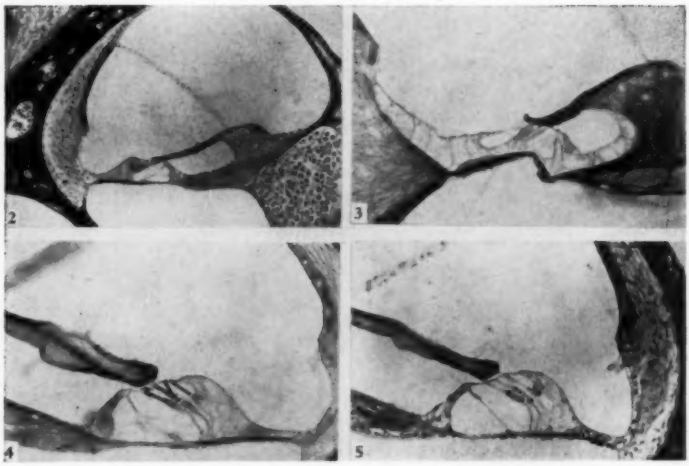

Fig. 2.—Section through the middle tier of the cochlea of a 20 days old rat. Toluidine blue, x120.

Fig. 3.—Section through the lower tier of the cochlea of a rat 20 days of age. Periodic acid-Schiff, x250.

Fig. 4.—Section through the upper tier of the cochlea of the animal in Figure 3. Periodic acid-Schiff, x250.

Fig. 5.—Section through the upper tier of the cochlea from a rat 20 days old. Periodic acid-Schiff-hematoxylin following bath in malt diastase, x237.

above the nucleus, there was a cap-like dense area, particularly apparent when stained with hematoxylin (Fig. 1) or toluidine blue, where it appeared basophilic. This cap-like formation seemed to be continued in form of a slender streak running lengthwise and terminating at the level of the globular body of Hensen, immediately under the hair. Next to this dark streak, a clear zone, unstained by either the PAS or hematoxylin, seemed to run a parallel course, occupying the axis of the cell (Figs. 1 and 6) and also extending up to Hensen's body. Whether the dark and clear streaks were two microscopic aspects of the same structure has not been clearly established. In phase contrast (Fig. 6) and in preparations stained by the PAS without an hematoxylin counterstain (Fig. 4), only the clear streak was apparent. In phase contrast (dark M.), it was sometimes possible to resolve the clear streak into a continuous row of clear, rounded or

ovoid formations arranged in a single row along the central axis of the cell. Laterally, the cytoplasma was filled with coarse granular masses which took the PAS strongly (Figs. 1 and 4). However, when the sections were pretreated with malt diastase, this reaction was not obtained (Fig. 5). Hensen's body appeared as a lighter, optically empty area in both the stained (Fig. 1) and unstained (Fig. 6) preparations. The hair appeared as a flat brush having the width of the cell. They seemed to emerge from the cell as individual free units but higher up, they seemed to become embedded in the overlying "cuticular membrane." In the free portion, they were moderately PAS positive (Figs. 1 and 6).

Three and possibly four cells on the outside of the sensory cells could be considered as the tall elements of Hensen (Figs. 1, 4, 5 and 6-a). Their apex was in form of a slender, tapered process which apparently joined with the processes of the adjacent cells; together these processes turned inwards to form the roof of the outer tunnel (Fig. 6-b); further inwards, they seemed to pass over the outer cells encompassing the free extremity of the hair (Fig. 6-d). Then they reached further inwards, under the membrana tectoria (Fig. 6-e) to eventually pass over the heads of the outer and inner pillar (Fig. 1). After this point, the very thin projection seemed to end as a filament resting between the tectorial membrane and the inner pillar cell; at least, it became lost from view. The cells of Hensen and their combined projections were practically unstained by the PAS.

By that criterion and also by their homogeneous appearance, the combined processes of the cells of Hensen moving inwards to form what has been previously described as the cuticular membrane[1,3] could be easily distinguished from the membrana tectoria. That large membrane showed the previously described peripheral affinity for the PAS (Figs. 1, 4, 5) characteristic of maturity. The PAS pattern remained constant after treatment with malt diastase. In phase contrast, the fibrillar content was very apparent (Fig. 6-e). The orientation of the tectorial membrane in the same plane as that of the outer hair cells was constantly observed (Figs. 1, 4, 5, 6). Its outer flattened, somewhat irregular extremity was separated from the cuticular membrane and the outer sensory cells underneath by a short space. This space however was bridged by three fine filamentous projections (Figs. 1, 6) attaching the membrana tectoria to the cuticular membrane and apparently to each of the sensory cells underneath.

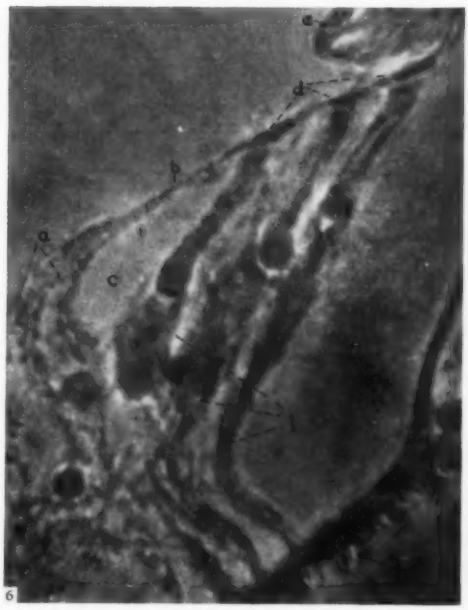

Fig. 6.—The outer portion of the organ of Corti. Radial section through the upper tier of the cochlea of a rat 20 days old. Dark M phase contrast micrograph: a, cells of Hensen; b, their combined processes (cuticular membrane); c, outer tunnel; d, outer sensory cells; e, membrana tectoria; k, outer pillar cell; j, basilar membrane; l, phalangeal cells of Deiters, x2000.

The outer phalangeal cells of Deiters (Figs. 1, 4, 5, 6) differed in shape and also in their PAS response from the inner phalangeal cell (Figs. 4, 5). The outer phalangeal cells were moderately stained particularly at the apex; the inner cell was negative. In dark M phase, the cytoplasma of the outer phalangeal cells (Fig. 6-l) was dark; that of the inner phalangeal cell was clear.

The other cells of the organ of Corti showed nothing remarkable. The basilar membrane was thin but apparently highly fibrillar. The acoustic strings were prominent in the PAS stained preparations before (Fig. 4) and after (Fig. 5) diastase hydrolysis. The vas spirale

was not visible in these mature portions of the organ. The stria vasculosa was moderately stained by the PAS before (Fig. 4) and after (Fig. 5) enzyme treatment.

Staining with toluidine blue. In a previous report,[8] the early immature tectorial membrane was described as exhibiting toluidine blue metachromasia, "persistent like that of mucus and the mast cells, after incubation with hyaluronidase." The present study has confirmed the previous observations on metachromasia of the mature and immature tectorial membrane, after fixation in formaldehyde-ethanol and also in tissue fixed in Bouin's mixture. The stain in the mature membrane was more even than that of the PAS. The metachromatic reaction faded rapidly in the inner attachment of the membrane over the limbus spiralis. The matrix of the bone and particularly that of the still present cartilage were remarkably metachromatic. The acoustic strings were moderately metachromatic (Fig. 2).

It is unfortunate that metachromasia and basophilia cannot be distinguished in a black and white photomicrograph such as in Figure 2. Several areas showed remarkable basophilia after the toluidine blue staining: the cytoplasma of the neurones in the ganglion of Corti, the stria vascularis, the cytoplasma of the outer sensory cells (apart from the central clear streak and Hensen's body) and the wide apical portion of the outer phalangeal cells.

Micro-incineration. Only sections of tissues fixed in formaldehyde-ethanol were, of course, submitted to micro-incineration. By comparison with the eye, the epidermis, hair and teeth often present in the same section, the ectodermic portion of the cochlea has left remarkably little ash in the spodogram.

COMMENT AND CONCLUSIONS

It is evident from the present observations that the cochlea of the rat is a very immature structure at birth. During the 20 some days of the lactation period, it differentiates rapidly. The specialization proceeds from the upper tier downwards and appears yet incomplete at that time.

The series of events (formation of the sulcus spiralis, tunnel, etc.) which mark the development of the organ of Corti, and also the sequence of these events seem to be in agreement with the description of the development of that structure in the human, as told by Kolmer[17]

yet this author claims that the maturation of the organ of Corti occurs between the tenth and the twentieth week of intra-uterine life. Kolmer also states that the differentiation begins in the basal turn and advances progressively towards the apex. The present material on the contrary seems to indicate progress in the maturation from the upper tier to the middle and lower tier (Figs. 3, 4). On the other hand, Keibel and Mall[18] quoting Siebenmann state that in the human the development of the membrana tectoria begins at 45 mm (11 weeks) "in the uppermost coil." The same authors also produce a drawing of the cochlea of a newborn child from Krause which shows a very immature organ of Corti in which the sulcus is filled with cells, the tunnel unopened and the tectorial membrane thin and closely apposed over the mound, a condition quite similar to the one described above for young rats of four to ten days. Arey[19] states briefly that the human ear is deaf at birth but at the same time describes the story of the cochlea, according to Kolmer.

The main events of differentiation seem to be the formation of the spiral sulcus which renders the tectorial membrane semimobile and the growth of the cells in the neuroepithelial mound, giving rise to the tunnel, to the sensory cells and also to the poorly understood Hensen cells. These have been shown here to develop an apical specialization very early and to form a thin membrane which stretches over the outer tunnel, the outer sensory cells and both pillar cells (cuticular membrane). In his recent description based on observations in phase contrast of fresh fragments of the cochlea of guinea pigs, Vago[3] has apparently observed the cells of Hensen and their processes joining with the outer sensory cells but without the help of a total image, he failed to recognize them and believed that they were the phalangeal cells of Deiters.

In its fully differentiated, most likely functional condition, the tectorial membrane forms a straight line with the outer sensory cells at 45° to the basilar membrane. It appears loosely attached at its extremity to the cuticular membrane and possibly also to the outer sensory cells (Fig. 1) by thin filamentous processes. Thus, much of the diversified opinions expressed in the literature[17,20-24] appear to contain some truth and can be somewhat reconciled in the light of the present evidence.

If one is permitted a flight of fancy at this point, it is possible in view of the observations reported here to consider the tectorial

membrane in function, as a strong fibrous structure tapping with its extremity on the cuticle and on the outer sensory cells, like the finger of a telegraph operator on his machine, or like the hand of a pianist moving in a wave-like motion across the keyboard. The fine filaments which unite the membrane to the underlying structure limit the range of displacement of the membrane making the movement a very gentle one. It is likely that the present material shows a relative arrangement of the structures which must be true to life. Even if the tectorial membrane is slightly pulled from its natural resting position, it is impossible to imagine any important lateral displacement without breakage of any one of the three very fine threads seen in Figures 1 and 6 and uniting the extremity of the membrane to the outer cells underneath. On the other hand, the combined processes of the cells of Hensen, directed inward seem to provide a strong binding and anchoring of the heads of the outer sensory cells, maintaining them constantly in proper alignment with the other components. This role appears particularly important in view of the assumed functional vibration and the evident fragility of the apparatus.

Histochemistry. The saccharides which have been studied here through the use of the Hotchkiss-McManus test and toluidine blue staining appear progressively with differentiation. The tectorial membrane shows very early the presence of highly polymerized saccharides reacting to the PAS after diastase treatment.[5-7,10] The fact that some of the polysaccharides are sulfated appear evident from the present and former observation of metachromatic staining[6,8] and autoradiographic evidence of radiosulfate incorporation. The acoustic strings, principally collagenous in nature are rich in polysaccharides also partly sulfated.

Very little material of that type has been observed in the sensory and supporting elements of the organ of Corti (Fig. 5), including the apical processes of the cells of Hensen (cuticular membrane). On the other hand, some highly stainable diastase-labile material, probably glycogen, is present in the superficial lateral cytoplasma of the outer sensory cells and was previously reported by Zorzoli.[4]

Intense toluidine blue basophilia in the ganglionic elements (Fig. 2), in the perinuclear portion of the outer sensory cells and also in the stria vascularis is indicative of concentrations of cytoplasmic nucleic acids (RNA).

Contrary to the photoreceptors of the retina to which they have been compared by Engström and Wersall or by the author, the sensory cells of the organ of Corti and also their supporting satellites leave very little ash after micro-incineration.

Cytology of the sensory cells. It appears evident from the present description that the outer sensory cells are different morphologically from the inner sensory cells. Functional reactions to sound waves recognized by Merkle[25] in the outer cells and not in the inner cells indicate that the former are more directly related to auditory perception. Their presently described relation to the tectorial membrane is in favor of this interpretation. The complex structure of their hair, undetected here, has been revealed by the electron microscope.[1,2] The cytoplasma of the outer cells has revealed a complexity not present in the inner cells: clear axial streak, basophilic perinuclear area and periaxial streak, superficial lateral layer rich in saccharides, Hensen's body. In fresh, unstained preparations, Vago[3] has observed a series of granules arranged along the axis of the outer cell and corresponding presumably to the presently described clear streak. They were very prone to post mortem changes, swelling into vacuoles and giving a pear shape to the degenerated cells. It is likely that functional ability is related to the full development and metabolic balance of these intracellular features. Proper maturation and maintenance of the supporting structures appear also essential. By such criteria, the rat is deaf at birth and has only partial cochlear function at the time of weaning.

SUMMARY

The organ of Corti in rats of 4 to 20 days has hereby been described from the histogenetic and cytochemical standpoints. The distribution of the saccharides retained by histological fixation has been particularly studied. In the mature organ, the outer sensory cells appear to be morphologically different from the inner sensory cell. A new appreciation of the cells of Hensen and their processes in relation to structure and function has been obtained.

Theoretical considerations on the transmission of vibrations and on the auditory ability of young rats have been presented.

UNIVERSITY OF OTTAWA

We acknowledge with gratitude the financial assistance of the Medical Division and that of the Committee on Dental Research of the National Research Council of Canada towards completion of this work.

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Scientific Papers of the American Broncho-Esophagological Association

XCII

AN ESOPHAGOSCOPIC TELESCOPE FOR EXAMINATION OF THE CARDIAC END OF THE STOMACH AND DISTAL ESOPHAGUS

JOSEPH P. ATKINS, M.D.

PHILADELPHIA, PA.

One of the unsatisfactory areas for the esophagoscopist is the distal end of the esophagus. This area and the cardiac end of the stomach constitute one of the most difficult diagnostic areas for the gastroscopist, esophagoscopist, radiologist and internist. In order to achieve more satisfactory visualization of this area, we have found that the use of a right angle telescope improves the exploration of the area. Our technique is to introduce a 9 x 53 full lumen esophagoscope into the stomach under direct vision in the usual manner. When the esophagoscope is definitely in the stomach, the telescope is then intro-

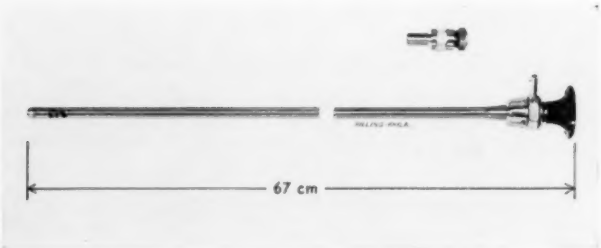

Fig. 1.—The right angle telescope is used through the esophagogastroscope. The telescope and occluding plug are ground to fit the proximal end of the endoscopic tube. The telescope is first introduced through the plug. As the telescope is introduced into the esophagoscope the plug occludes completely the proximal end of the tube. It is possible to push the telescope in and out while maintaining inflation of the stomach and distal esophagus.

From the Broncho-Esophagologic Clinics of the University of Pennsylvania.

duced as far as, but not beyond, the end of the esophagoscope. By means of a specially devised cuff, an air tight closure is made at the proximal end of the esophagoscope. The stomach is then inflated; when inflation has been accomplished the esophagoscope is withdrawn leaving the telescope in its original position. By means of this initial inflation, the lens of the telescope is kept clean so that satisfactory visualization of the cardiac end of the stomach may be obtained. The telescope is withdrawn until the wall of the esophagus covers the objective lens of the telescope. This instrument is useful in examination of the cardiac end of the stomach, hiatus hernia and particularly in examination of the postgastrectomy stomach where no other instrument permits a comparable view of the stomach remnant. The telescope is 67 cm long and 8 mm in diameter.

3400 SPRUCE ST.

XCIII

A MODIFICATION OF THE STANDARD JACKSON LARYNGOSCOPE

William A. Lell, M.D.

Philadelphia, Pa.

In this modification of the standard Jackson laryngoscope, the little removable metal slide piece on the posterior part of the instrument is entirely eliminated. In this change the open groove is located on the right side of the instrument and remains permanently open (Fig. 1).

I believe that this change gives greater adaptability of the Jackson laryngoscope in the following ways:

1. Wider field of visualization at the tip.

2. Greater feasibility of instrumentation particularly in the introduction of the bronchoscope.

3. Greater ease in the withdrawal of the laryngoscope without having to worry about removal of the metal slide clip which may become stuck and occasionally even lost.

4. Clear visibility during intubation under direct visualization which was impossible previously by using the conventional Jackson laryngoscope.

5. Further adaptability to the many uses of the Jackson standard laryngoscope.

255 S. 17th St.

XCIV

A SHADOWLESS WIDE FIELD OPERATING LARYNGOSCOPE

GABRIEL F. TUCKER, JR., M.D.

BALTIMORE, MD.

AND

JOSEPH P. ATKINS, M.D.

PHILADELPHIA, PA.

We would like to present for your consideration an anterior commissure laryngoscope which is really a synthesis of a laryngoscope presented before the American Laryngological Association in 1940 by Dr. Gabriel Tucker and a laryngoscope presented before the American Broncho-Esophagological Association in 1947 by Dr. Edwin Broyles. The feature which Dr. Broyles presented in his laryngoscope was a narrowing of the proximal end to permit easier manipulation for the laryngoscopist and greater comfort for the patient.

The instrument presented by Dr. Gabriel Tucker was equipped with twin illumination which permitted a forceps to be introduced into the laryngoscope without producing a shadow. These shadows are objectionable because they frequently fall on the lesion that one is attempting to remove thereby reducing the accuracy of the removal. A second important feature in Dr. Tucker's laryngoscope was the proximal extension of the lumen of the tube, so that the laryngoscope could be introduced deeply without the annoying accident of falling behind the upper incisor teeth. This permits more satisfactory examination of the subglottic larynx and upper trachea. It makes biopsy of the upper trachea through the laryngoscope feasible.

In combining these features of these two instruments, we feel that we have a laryngoscope which can be used very satisfactorily by the laryngoscopist and at the same time is well tolerated by the patient. An instrument which makes subglottic and upper tracheal lesions more accessible to endoscopic surgery, overcomes annoying

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From the Department of Otolaryngology Johns Hopkins Hospital and the Broncho-Esophagologic Clinics of the University of Pennsylvania.

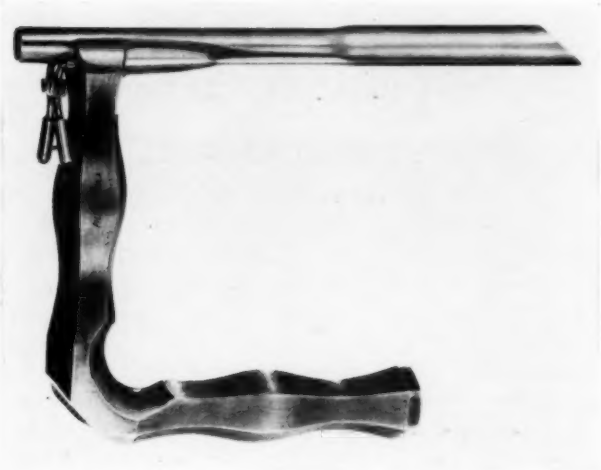

Fig. 1.—The Tucker-Atkins wide field operating laryngoscope. (The George P. Pilling & Son Co., Philadelphia)

shadows, is easier to use, and is well tolerated by the patient should be a useful addition to the endoscopic armamentarium.

JOHNS HOPKINS HOSPITAL

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XCV

A TRACHEOTOMY TUBE FOR MAXIMAL PULMONARY VENTILATION

JOSEPH P. ATKINS, M.D.

PHILADELPHIA, PA.

Tracheotomy is used more and more frequently for the prevention of respiratory complications in patients suffering from a loss of the expulsive mechanism of the lungs. The tracheotomy tube reduces the danger of aspiration of gastric and pharyngeal secretions, permits removal by aspiration of bronchial secretions and thereby maintains pulmonary ventilation. The tracheotomy tubes now commonly in use are quite satisfactory in the majority of cases to protect these patients.

Where there is severe reduction in pulmonary function even slight interference with ventilation may produce injury to the patient. Examples of such situations might be severe pulmonary emphysema or acute injury such as a serious burn of the tracheobronchial tree. In such situations the amount of lung available may be critically near the point at which there is just adequate ventilation for survival. Under these circumstances any interference in ventilation whatsoever must be avoided. A tracheotomy tube which offers resistance to air flow reduces ventilation. At the same time it forces the patient to breathe through the mouth thus creating the likelihood of aspiration of pharyngeal contents.

It appeared worthwhile to determine whether significant improvement in ventilation might be achieved by the use of larger tracheotomy tubes than those now in common use. For this purpose three new tracheotomy tubes were devised: sizes 8, 10 and 12. The airway resistance of these tubes was compared with standard No. 6 tracheotomy tubes. These were measured by the Pulmonary Function Section at the University of Pennsylvania Hospital. According to their measurements, the resistance of the normal airway is about 1½ cm of water per liter per second. The resistance of the No. 6 tube was found to be significantly greater than this, whereas the new tubes were found to be significantly below (Table I).

From the Broncho-Esophagologic Clinics of the University of Pennsylvania.

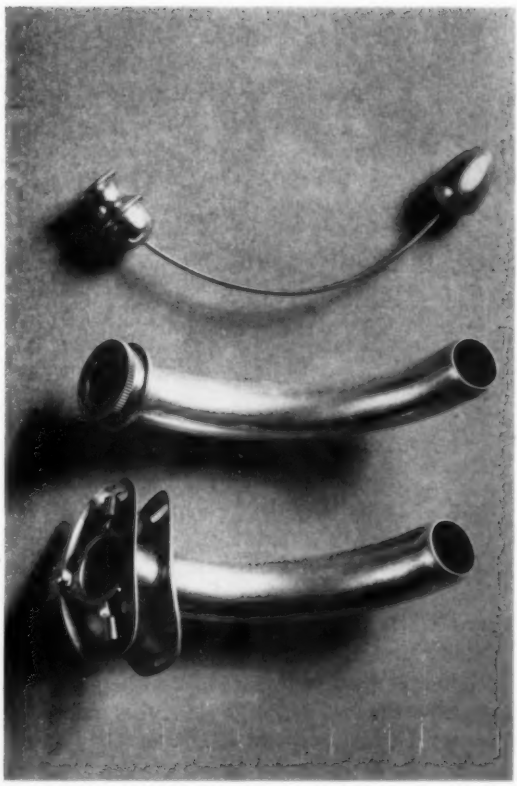

Fig. 1.—The author's extra large tracheotomy tubes, with double shield for convenience in maintaining a clean dressing, in sizes devised to permit maximal pulmonary ventilation. (The George P. Pilling and Sons Co., Philadelphia)

TABLE I

1. WATER MANOMETER METHOD

Flow Rate: 2.0 liters/second

Tracheotomy

Tube Number:	No. 6	No 8	No. 10	No. 12
Water Manometer measuring pressure drop across tube	4 cm. H_2O	1.8	.4	.1
Resistance (Pressure drop) / (Flow rate)	2.04 cm. H_2O liters/second	.72	.20	.05

2. OSCILLOSCOPE METHOD

Flow Rate: 1.2 liters/second

Tracheotomy

Tube Number:	No. 6	No. 8	No. 10	No. 12
Resistance	3.0 cm. H_2O liters/second	.22	.15	off scale

The new tracheotomy tubes have been devised with a double shield (Fig. 1) so that it might be attached to the patient's neck and a loose dressing applied between the two shields. These dressings can be removed when soiled without the necessity of changing the tube or disturbing its attachment to the neck. The No. 12 tube was found to be generally too large for introduction into the trachea. It is our feeling that the No. 8 and 10 size tubes will generally suffice in view of the resistance figures noted above.

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Society Proceedings

CHICAGO LARYNGOLOGICAL AND OTOLOGICAL SOCIETY

Meeting of Monday, December 5, 1955

THE PRESIDENT, DR. PAUL H. HOLINGER, IN THE CHAIR

Technique of Tonsillectomy and Adenoidectomy (Motion Picture)

LINDEN J. WALLNER, M.D.

(Abstract)

Tonsillectomy is the most common surgical operation and it is natural that there should be a great variety of instruments and methods available for its performance. Almost any of these are satisfactory to the surgeon experienced in their use.

The head low or so-called "upside down" position with the Crowe-Davis mouth gag is becoming more commonly used in this country, indicating certain inherent advantages. These may be listed:

1. The airway is maintained by holding the tongue and hyoid structures forward.

2. Blood and secretions drain away from the larynx and the operative field.

3. Excellent exposure is obtained without constant manipulation of the tongue. This encourages meticulous removal of lymphoid tissue and complete hemostasis.

4. No assistant is necessary.

This method has certain advantages when the anesthetist is required to support the handle of the tongue blade manually. It becomes heavy and fatiguing as he is working with poor leverage.

Since he is not viewing the throat it is difficult to know when the head is correctly held. If the tongue blade is not supported properly the head may become flexed, obstructing the airway by allowing the epiglottis to fall against the posterior pharyngeal wall. Frequent movement of the tongue blade may place a strain upon the upper teeth.

Because of these difficulties the tongue blade is often hung or supported from the frame of a Mayo instrument stand. This was found to be an improvement but not entirely satisfactory. The stand is not rigid and tends to slip on the floor, so that frequent readjustment is necessary. Also the tilt of the table for the Trendelenburg position cannot be adjusted without first disengaging the tongue blade.

The Killian gallows used for suspension laryngoscopy seemed to offer a stronger and more rigid support for the Crowe-Davis tongue blade. The two screw handles allow delicate adjustments horizontally and vertically. As the gallows is attached to the table the tilt may be altered without disconnecting the tongue blade.

This method of supporting the Crowe-Davis and McIvor tongue blade has been used for the past three years with most satisfactory results. The new Barton tongue blade for the endotracheal tube fits either the Crowe-Davis or McIvor mouth gag, and may be supported from the arm of the gallows in a similar manner.

DISCUSSION

DR. ARTHUR J. COOMBS: Those of us who know Dr. Wallner know that he does not present anything that has not been worked out meticulously, and this is an example. Some of it is elementary, which is all right because it is presented as a teaching film. It has a place in teaching students and internes as well as residents on the technique of tonsillectomy.

I think the Barton tongue depressor should be called the Barton tongue elevator. We should forget depression of the tongue and speak of it as elevation—it is to hold the tongue away from the area so the airway is clear.

Like most of you I was taught to use the supine position, but there was difficulty in maintaining the airway. Not infrequently it was necessary to perform artificial respiration. About 1943 I had

an opportunity to try the endotracheal method at the suggestion of an anesthetist; he was anxious to have the utmost in safety in this particular case (a doctor's son). Several times during the operation I stopped to watch the chest, and it was amazing to see how quiet the respirations were. A large number of cases were performed under endotracheal anesthesia. Later we tried the Rose position, with a tube in the side of the mouth; this position was excellent. Dr. Wallner's picture shows how it is done and how the blood is kept away from the airway. When removing the adenoids it was necessary to change positions and stand by the side of the patient's head. By using the Shambaugh instrument I can see how it would be possible to remain seated as during the tonsillectomy procedure, but I think we still must come around to the side of the patient to get a really adequate visual exposure of the nasopharynx and to remove any tags. That criticism is still not too much against the Rose position.

After performing quite a number by this technique, I went back to endotracheal anesthesia and have stayed with it. The procedure has recently been somewhat modified by using Inectin, which is known chemically as Succinylcholine. The patient is first put to sleep with nitrous oxide, then Inectin is given intravenously. Within three minutes complete relaxation of the vocal cords takes place. I was struck with the unusual visibility of the glottis. After the Inectin is used, cyclopropane with a certain amount of ether is used for the remainder of the operation. At the conclusion of the operation it is only a matter of minutes before the patient awakens sufficiently to clear any blood out of the throat, and by the time he is back in the room it is surprising how far he has recovered; it is not necessary to keep patients in the recovery room.

We use a modification of the Jennings instrument known as the Wolff mouth gag which elevates the tongue away from the posterior wall. If I were starting in practice now I would use the technique we are using with endotracheal anesthesia. If I did not have adequate assistance I would want to use the bracket Dr. Wallner devised; with our present help we do not need it. If the anesthetist were not skilled in the endotracheal technique I would use the Rose position. If I had to go back to the old method under which we were trained, I would prefer to give up doing general tonsillectomies.

Dr. Linden J. Wallner (closing): I wish to thank Dr. Coombs for his discussion. With regard to direct vision adenoidectomy, if one wishes to do it routinely the usual supine position is probably the best. I would like to refer Dr. Coombs to an article by

Dr. Fordyce Johnson. He has a special instrument to remove adenoid tags. He sits at the head of the patient in the Rose position, and uses a laryngeal mirror to visualize the adenoid area.

Carcinoma of the Larynx

CHEVALIER L. JACKSON, M.D.

PHILADELPHIA, PA.

DISCUSSION

DR. MAURICE F. SNITMAN: During the 1942 meeting of the American Academy of Otolaryngology an exhibit was presented on the management of carcinoma of the larynx. Depending on the anatomy of the lesion, the treatment was divided into three categories; partial laryngectomy (laryngofissure), total laryngectomy, and irradiation. Since then great strides have been made especially in the management of those cases that were formerly treated by irradiation. Most cases today undergo surgical resection. In most instances the surgical resection includes simultaneous radical neck dissection. In the Department of Otolaryngology at the University of Illinois, irradiation is reserved for those cases where surgical resection of the primary or secondary lesion is not feasible. Rarely do we find a nonsurgical primary lesion in the pharynx or larynx.

In some of the cases presented by Dr. Jackson, treatment by partial laryngectomy would appear to be inadequate surgery. Perhaps his immediate good results may be explained by several slides I will now present. They show that although the lesion may appear to be extensive, it does not invade into the curd musculature but rather remains fairly superficial as an extensive papillation.

Partial laryngectomies for laryngeal lesions, which are much more extensive than the generally understood laryngofissure lesions, could be a hazard recommendation for the less experienced surgeon.

Our studies of immediate results during the past five or six years clearly illustrate a projected increase in the five-year survival rate where total laryngectomy or laryngopharyngectomy is combined with a radical neck dissection, even in the absence of clinical metastatic adenopathy.

DR. THOMAS C. GALLOWAY: I appreciate the honesty and clarity and conservatism of Dr. Jackson's presentation. If I were to have a carcinoma of the larynx I would like the approach to treatment to be the same.

I have always stressed in borderline cases the greater danger of performing laryngofissure rather than laryngectomy, but have justified it by the more normal life permitted the patient. In earlier years I saw many disappointing results with irradiation. Recently I had the opportunity of seeing the fine work of experts like Dr. Hamman and I now feel that irradiation in some cases in which one does a laryngofissure would give almost as good a result without too much danger to the patient. One thing that disturbs me is, how often is radical neck dissection worth while. My own impression is that when there are glands which must be removed, the lesion is already locally metastatic and it is doubtful if one can clear out all the nodes. But I was impressed by Clerf's study reported last year of five-year cures by that technique. Before making up my mind I shall wait until Dr. Snitman and others are ready to submit a larger series of five-year cures.

As I grow older I see younger men going through the same stages I did, with early enthusiasm for each new method. I think we should not create over-enthusiasm, but, in spite of the fact that statistics do not show much improvement in our results, we should never give up trying to cure carcinoma of the larynx.

DR. ROBERT B. LEWY: We are as always greatly indebted to Dr. Jackson for a very illuminating and instructive presentation. It leaves little to add, other than perhaps to re-emphasize the tremendous importance of a most careful and painstaking examination to establish the correct diagnosis. This is, of course, the prime requisite for successful and proper work in any medical situation.

I wish to present two slides of an interesting instance in which carcinoma of the larynx might easily have been overlooked. This patient had had an indirect mirror examination by two attending men and three residents at Hines V.A. Hospital. The provisional diagnosis was benign neoplasm of the vocal cord. Carcinoma was not suspected. It was proved, of course, by biopsy. Had the naked eye visualized the process as well as the camera did, we probably would have suspected the correct diagnosis at least at the time of laryngoscopy. The conclusion may be justified that the camera may well become a diagnostic as well as an educational instrument.

The pictures were taken through a standard operating tubular laryngoscope. This was the Jackson anterior commissure type modified with the flare at the tip, suggested by Dr. Holinger. The larynx was made available and exposed for photography by getting the laryngoscope and the patient in an appropriate position. This was achieved and maintained by placing three folded sheets in the interscapular region, extending the head on the first cervical vertebra and placing the vertex of the head on the operating table. The scope was drawn into position with the gear-powered laryngoscope holder. Some of you may be familiar with this from prior meetings of this Society. This established a completely stable system and no head holder was required. There was therefore free access of the viewing end of the laryngoscope to the camera.

(The slides showed a) one biopsy taken, b) fine vessel arborization and c) the second slide showed the continuation of the carcinoma downward subglotticly. The pictures were taken by Dr. Richard Buckingham.)

Dr. John R. Lindsay: I cannot refrain from rising to compliment Dr. Jackson for this excellent presentation, something which we have, of course, learned to expect from him. I was pleased to hear him say that he felt that irradiation had a place. I think we must recognize not only that surgery has made progress, but that irradiation has also. As a matter of fact, if we look at statistics, the old statistics on cures by irradiation are not worth giving. Most of those patients were considered to be hopeless for surgery and were turned over for radiation. In the same way our surgical statistics were perhaps better a few years ago than now, because we are now accepting cases for surgery where there is extension to glands in the neck, because we know irradiation is of no use.

We have had a chance to see a good many cases given irradiation for one reason or another at our institution, and I am of the opinion, as is Dr. Galloway, that in very early cases the results from carefully controlled irradiation are not far different from surgical results. In these cases there might be certain considerations which might influence one toward irradiation, such as preservation of the voice. One reason for trying irradiation is that you can observe the lesion easily after treatment. If there is persistence of the lesion or recurrence surgery should be done promptly.

I would like to make another point about irradiation therapy. It is not a simple form of treatment. The discomfort and annoyance

these patients go through are a great deal worse than following radical surgery. The only advantage is that you may be able to preserve a better voice.

DR. FRANCIS LEDERER: I believe my role is to finish the story that Dr. Jackson started. However, I would qualify it by telling you that when statistics come from a source such as Dr. Jackson, you will grant that they have been assembled after most careful and painstaking study and follow-up, a better follow-up than many of us have on our cases. However, statistics should be interpreted individually, as is well supported from what he has presented and from your own experience. Statistics are said to be like Bikini bathing suits—what they reveal is interesting but what they conceal is vital!

Since Dr. Snitman came from Canada originally I want to interpret for the audience and for Dr. Jackson what he said. In truth, he does not differ from Dr. Jackson. Dr. Jackson is of the same opinion that lesions with mobility can be irradiated, and I am sure that, with the number of slides Dr. Snitman has studied and the experience he has had, if he had to have his larynx removed he would resort to radiation because he knows in this superficial type of lesion that radiation and surgery are neck and neck for statistical honors. Dr. Jackson has grown up in laryngology with many of us and we have kept pace with him and, we hope, with the progress in the world of laryngology. It is always that considered attitude in search for the correct solution that has inspired Dr. Jackson and his illustrious father before him. Therefore, the same feeling has prompted him again to take on the indications for a procedure that will serve to conserve the larynx and yet cure the patient of his malignant disease.

There is some reason for spreading alarm when one expresses conservatism in the treatment of malignant disease. I will tell Dr. Galloway that it is not all inspired by the enthusiasm of youth. I regard with alarm the attitude of conservatism about epiglottic carcinoma. I would be rather wary about thyrotomy, for even the centimeter rule is not to be relied upon completely. Of course, Dr. Jackson was the clinician and he was also a surgeon, and he is the best judge of the indications. His five-year statistics are to be taken very seriously. Dr. Snitman is working in an atmosphere of hopelessness when it comes to seeing the far advanced type of material we observe in our clinics. Years ago when wonderful statistics of the cure rate of brain abscess came from the Mayo Clinic, we did not suspect those people of exaggeration. When the brain abscess local-

ized, there was a 4 diopter choked disc, the patient outlived his encephalitis and his outlook for cure by surgical drainage was great.

The last cases Dr. Jackson demonstrated on his slides are similar to the ones shown by Dr. Snitman. In patients having only epiglottic involvement, we would agree concerning neck nodes. We are grateful to Dr. Jackson for his excellent presentation. We did not invite him here to pat him on the back. We are aware that his statistics have not altered appreciably. Since 1950 he has been tackling material surgically that he would never have recommended for surgery before. His present 69 per cent survival rate must be interpreted in the light of the less localized carcinomas of the larynx that he now chooses for surgical intervention.

Dr. C. L. Jackson, Philadelphia, Pa. (closing): After such a nice speech as Dr. Lederer has just made, I think anything I could say would be an anticlimax. I expected much rougher treatment. I do not feel that Dr. Snitman or anybody else has been unkindly in the discussion.

One or two statements were made upon which I wish to comment. As for the Alonso technique, I agree with Dr. Snitman that we should emphasize the importance of proper selection of cases in which it is to be used. The same thing applies to laryngofissure and to other types of partial laryngectomy. I would like to say, as I have said many times before, that my interest in these techniques leads me to emphasize just as strongly as I can both the selection of cases and the techniques of the operations, because there is nothing more unsatisfactory than a poorly done laryngofissure in an improperly selected case.

I agree with Dr. Galloway that evaluation of elective neck dissection will take time. We are trying to accumulate statistics that will be of value in helping us decide just which cases call for that procedure.

In connection with Dr. Snitman's comment about taking out the thyroid cartilage, I should like to say that his slides were very interesting and very illuminating, but I want to explain the reasons for which at the present time we are taking out the cartilage. It is not so much because of the possibility of extension into the cartilage as because with this technique examination of the operative specimen gives a better chance to see how complete a removal of the soft tissue has been obtained. The other reason is that removal of the cartilage gives a better voice.

Meeting of Monday, January 9, 1956

THE PRESIDENT, DR. PAUL H. HOLINGER, IN THE CHAIR

Osteogenic Sarcoma of the Skull Following Irradiation

EMANUEL M. SKOLNIK, M.D.

ELIO J. FORNATTO, M.D.

J. HEYDEMANN, M.D.

R. V. HOFFMANN, M.D.

CHICAGO, ILL.

(Complete paper appears on page 915)

DISCUSSION

DR. JULIUS HEYDEMANN: There is very little to add. The two cases reported received a large amount of irradiation, 6000 roentgens in the first case in nine months; this is a cancercidal dose used for a benign lesion. The second also received a large dose of radium which was given nearly continuously over a period of thirteen months.

We feel that irradiation should be given when indicated; but if a benign lesion does not respond to treatment one should not repeat irradiation; another form of therapy should be instituted. The repeated use of irradiation or the prolonged use of irradiation may produce a sufficient amount of reaction in normal tissue to eventually produce cancer, as reported in the cases presented.

DR. L. B. BERNHEIMER: I am not sure that a direct relationship between the cause of sarcoma and irradiation has been established in the two instances cited. It is true that skin exposed to an amount of irradiation undergoes malignant degeneration, but this is always preceded by long periods of irritation due to post-irradiation atrophy and necrosis. The same is true of epithelial membranes in general. It is further known that the ingestion of radium, which has occurred among individuals working this element, results in osteosarcoma. However, before osteosarcoma develops there is a long period of atrophy and bone necrosis. Furthermore, the ingested radium remains active for many years, while an irradiated tissue is active for only about six weeks.

Nasopharyngeal carcinoma has been reported following the use of the Crowe applicator. I have seen an amount of nasopharyngeal carcinoma and have used the applicator, but in my experience there has been no evidence of causal relationship. Carcinoma of the thyroid has been reported as a result of irradiation of the tonsils and adenoids. In the 12 instances of such juvenile neoplasms which I have seen none has received irradiation and Dr. Uhlmann has reported that although he has treated 2500 children with x-ray for hypertrophied tonsils and adenoids, none developed malignancy of the thyroid.

I do not believe that irradiation should be considered as the causative factor of neoplasm without being preceded by long periods of post-irradiation atrophy, necrosis and irritation.

DR. JOHN R. LINDSAY: Dr. Bernheimer's remarks have brought to mind a recent case of carcinoma of the mastoid, starting primarily in the mastoid, not as a result of suppuration or any localized irritation. This is the third case of this particular type of which I know. All were patients who had been painting watch dials in an Illinois town more than 25 years ago. These three cases developed carcinoma in a mastoid which was apparently healthy. Apparently the mastoid is susceptible to this type of irradiation; possibly because the epithelium is so close to the bone in the mastoid cells that it is subject to a larger amount of radiation from the bone in which the radium is stored. I think we must have great respect for irradiation, especially in early life, and the possibility of its causing malignancy in later years.

DR. THOMAS C. GALLOWAY: I should like first to compliment the authors on this splendid presentation. There is a terrific mass of material accumulating on the effects of irradiation. We know the latent period of x-ray is at least three to four years, and I think it should be counted from the first application rather than the last. Dr. Dwight Clark saw 15 cases, 13 of which had had previous irradiation therapy for thymus or tonsil disease, followed by carcinoma of the thyroid. I had a classmate who had the idea that radium water was good for rheumatism, and not only did he take it but he gave it to his patients, with some disastrous results. He died about two years ago with osteogenic sarcoma. It does not matter too much if we treat an older person whose life expectancy is not too great, with irradiation for malignancy, but more serious consideration should be given to treatment of young children who have a long expectancy and in whom bad effects may be seen much later. In the case re-

ported here, this sarcoma seemed to arise from multiple areas and each ran wild.

DR. FRANCIS LEDERER: I arise with justifiable pride to hear Dr. Fornatto pinch hit so effectively for Dr. Skolnik. This is an historic occasion for me, because some 25 or more years ago, Dr. Bernheimer presented, along with Dr. Max Cutler, the radiologist, a paper on the treatment of hyperesthetic rhinitis with radium. At that meeting I protested that radium was something lethal, not to be considered lightly and that it would be possible to substitute for this a sneezing condition which the Germans call "stink nase" or "ozoena."

Recently I saw one of these patients at the Infirmary, not only with atrophy but with a large perforating lesion in the posterior portion of the septum. Perhaps if she survives we may later see other effects of irradiation. I too have recorded in the literature of 1922 and 1949 that I have not observed carcinoma in any cases that had irradiation to the pharynx and nasopharynx, but we have seen other forms of malignancy that have been engendered through irradiation. I think we miss the point if it is thought that we are saying that irradiation is not an effective treatment for malignancy. It was pointed out, however, that for benign lesions we must be cautious in its use. The essayists lay down certain rules which we need to follow. Dr. Fornatto mentioned the statistics, which are meaningful but, as Dr. Galloway stated, the danger is ever present. We are also to be cautioned, especially when we meet a dentist friend with missing fingers, a hand, or even an arm, due to lack of caution with irradiation. The same thing can happen not only to us but to our patients with the injudicious application of a modality such as radium or x-ray.

DR. PAUL H. HOLINGER: I might mention three patients whom we reported some years ago and one additional patient seen since that report, who developed carcinoma in areas previously irradiated for nonmalignant lesions. Three of the patients had received irradiation for tuberculous lymphadenopathy and the fourth for a benign thyroid enlargement. The carcinomas developed between 16 and 32 years after irradiation. The dosage was unknown, because in each case it had been administered in the office of a radiologist who had since died and his records no longer existed; but extensive skin changes in each of the four patients indicated that high dosages had been given.

DR. ELIO J. FORNATTO (closing): I want to thank the discussants for their interesting remarks. Dr. Bernheimer mentioned the

action of radon in the production of malignancies. I am sure he meant radium because radon has a short action. A considerable amount of experimental and clinical study has been done on the subject, and it seems that there is a definite relationship between irradiation and the development of malignancies. It seems that after prolonged irradiation bone growth becomes atypical and the malignancy develops. It is hard for me to believe that irradiation is not a factor in the development of osteogenic sarcoma, when we know that these areas have been irradiated so heavily for such a long time. It must be at least a very important co-factor.

The judicious use of irradiation is important, but for benign conditions we believe surgery is better; we avoid the dangers of irradiation and we have a specimen for histologic study.

Surgery of the Neck

BRUCE PROCTOR, M.D.

DETROIT, MICH.

The otolaryngologist is frequently confronted with problems of diagnosis and treatment in diseases of the neck. It is necessary then to be familiar with the embryology, anatomy, physiology, pathology and surgery of the region. A properly trained otolaryngologist is the one most qualified to treat the various diseases peculiar to this region. The object of this presentation is to review rapidly the surgical anatomy of the neck and to emphasize the clinical aspects of the structures and pathology found therein.

FASCIA

The neck has an external supporting (investing) fascia which is attached above to the mandible and to the superior nuchal line of the occiput. Below it is attached to the sternum and clavicle. This fascia firmly surrounds and supports the entire neck.

Within the external supporting fascia is another fascial system surrounding and supporting the viscera of the neck (larynx, trachea, pharynx, upper esophagus and thyroid gland). This inner tubular fascial system is mobile and permits movements of the viscera with respirations and swallowing. The anterior portion of this fascia is

known as the pretracheal fascia. The posterior portion is the buccopharyngeal fascia.

A third fascial system is the prevertebral which covers and supports the anterior and lateral aspects of the various muscles attached to the cervical vertebrae.

THE MEDIAN NECK

This region is concerned with the surgery of the trachea and larynx. It embraces the strap or ribbon muscles of the larynx, the thyroid isthmus, the hyoid bone, thyrohyoid membrane, anterior jugular arch and at times the upper end of the thymus gland.

THE SUBMAXILLARY AND CAROTID TRIANGLES

These two triangles are separated by the posterior belly of the digastric muscle. The former is limited by the anterior belly of the digastric muscle and by the mandible. Structures of importance in this triangle are the submaxillary gland, the facial artery and vein, the cervical branch of the facial nerve. Deep in this triangle are the hypoglossal nerve and the lingual vein.

In the depth of the digastric triangle are the muscles of the floor of the mouth. They may best be remembered as being arranged in four layers. In the outer layer are the digastrics and stylohyoid muscles. The second is the mylohyoid muscle. The third the hyoglossus and styloglossus muscles and the fourth the geniohyoid and genioglossus muscles.

The carotid triangle is bounded posteriorly by the anterior border of the sternomastoid muscle and anteriorly by the larynx. In this triangle are the great auricular nerve; common facial vein, common, external and internal carotid arteries; superior thyroid, superior laryngeal, lingual, facial, occipital, posterior auricular and ascending pharyngeal arteries; corresponding veins and jugular vein; the carotid sheath enclosing the carotid arteries, internal jugular vein and vagus nerve lies in this triangle. The hypoglossal nerve crosses laterally on the sheath and as it does so it gives off the descending hypoglossal nerve which in turn unites lower on the sheath with the descending cervicis nerve to form the ansa hypoglossi. The superior laryngeal nerve lies near the anterior aspect of the carotid sheath. The sympathetic trunk lies behind the sheath. The glossopharyngeal nerve passes anteriorly between the internal and external carotids at a high

level in the triangle. High in the triangle the spinal accessory nerve leaves the lateral aspect of the carotid sheath to pass posteriorly through the posterior triangle.

The posterior belly of the digastric muscle is a key structure in this region. Only three relatively unimportant structures lie superficial to it. These are the cervical branch of the facial nerve, the greater auricular nerve and the common facial vein. Directly beneath this muscle lies the contents of the carotid sheath and the last four cranial nerves.

POSTERIOR TRIANGLE

Limited anteriorly by the sternomastoid muscle and posteriorly by the trapezius muscle. The apex is at the superior nuchal line of occiput and the base is at the clavicle. Inferiorly the triangle is crossed by the inferior belly of the omohyoid muscle. The spinal accessory nerve crosses posteriorly and inferiorly in the midportion of the triangle. The triangle is shallow and is limited medially by the prevertebral fascia. Much of the triangle is occupied by fatty tissue and lymph nodes.

BOOT OF THE NECK

This is the region lying beneath the sternomastoid muscle and below the omohyoid. It contains the internal jugular and subclavian veins, thoracic duct, common carotid and vertebral arteries, thyrocervical arterial trunk, and the vagus and phrenic nerves. In the depth lies the scalenus anticus muscle behind which lie the subclavian artery, brachial plexus and recurrent laryngeal nerve.

TRIANGLE OF THE VERTEBRAL ARTERY

This is limited inferiorly by the pleural dome, laterally by the scalenus anticus muscle and medially by the longus cervicis muscle. Contained in this triangle are the vertebral artery, recurrent laryngeal nerve, ansa subclavia and the inferior and middle cervical ganglia. Posteriorly lies the lower portion of the brachial plexus.

PRACTICAL CONSIDERATIONS

Radical Neck Dissection. The object of this operation is to remove the cervical lymph nodes distributed along the internal jugular vein in an attempt to remove metastatic carcinoma in these nodes. The primary site of carcinoma must of necessity be controlled.

A single incision along the entire anterior border of the sternomastoid muscle usually suffices. The external jugular vein should be secured immediately before contraction of the platysma muscle retracts it. This vein when severed is a source of air embolism. Early in the course of the dissection the cervical branch of the facial nerve should be identified and pains taken to preserve it.

The internal jugular vein is isolated as low as possible in the neck. It is wise to tie four ligatures around this vein and to cut between the second and third ligatures. Care must be taken so as not to include the vagus nerve when placing the ligatures around the vein.

All fatty tissue is swept out of the posterior triangle. In almost every case it is necessary to sacrifice the spinal accessory nerve because of the proximity of metastatic nodes.

In most instances it is necessary to resect the digastric and stylohyoid muscles. This permits a cleaner dissection to a much higher and safer level. The upper end of the jugular vein should be tied with two ligatures and the vein cut across below the second. In the event that the vein is torn off at a level higher than can be reached to ligate an oxycel plug can be inserted to control the bleeding.

Branchial Cysts. These arise as a result of abnormal obliteration of the embryonic branchial apparatus most commonly the second ectodermal cleft. The cyst lies in the carotid triangle where it is exposed immediately upon incising the envesting fascia. At this point it is well to deflate the cyst by aspirating its liquid contents. Blunt dissection around the external cyst wall will usually free it completely. Care must be taken in freeing the medial end where it is most firmly attached, usually to the internal jugular vein. Every attempt must be made to remove any extension medial to the carotid sheath.

Branchial Fistula. This form of congenital defect is due to failure of closure of a branchial cleft and its corresponding pouch, usually the second. The internal opening is in the region of the upper pole of the tonsil. The tract passes between the internal and external carotid arteries.

Fistulas of third cleft and pouch origin are rare. They pass behind the common carotid and have their internal opening in the lateral wall of the hypopharynx or in the region of the laryngeal ventricle.

The step-ladder type of incision is recommended in removing these fistulae. The lower incision should include the external orifice of the fistula and any adjacent abnormal skin. The second incision is made transversely at the hyoid level where these fistulae turn inward to pass between the carotids. The internal opening of the tract may be excised along with the tract. At times the inner portion of the tract is adherent to surrounding tissues in which case the tract may be inverted into the pharynx and then removed by the oral route.

Thyroglossal Duct Cyst. These arise as a result of the failure of the thyroglossal tract to disappear completely. Remnants of the epithelial lined tract may be left at any point along the embryonic route of the tract. Since the tract is closely related to the body of the hyoid bone it is recommended that the body of the hyoid be removed in these cases in order to prevent annoying recurrences. Every effort should be made to cone out the tract and adjacent muscle in the interval between the body of the hyoid and the foramen cecum.

Time and space does not allow an adequate dissertation on neck surgery. What must be stressed is that a basic knowledge of anatomy, embryology, physiology and pathology of the structures in the neck is essential in doing this surgery. Preoperative diagnosis is often at best only on a differential basis. Often times the true diagnosis does not become apparent until surgery is under way. One must always be prepared to alter the surgery to fit any situation at hand.

DISCUSSION

DR. M. F. SNITMAN: The publication of a program containing a discussion of head and neck surgery should be to many of us most gratifying, especially so when it is sponsored by an ear, nose and throat society. Dr. Proctor's difficulty in advancing this type of work is keenly appreciated. Dr. Lederer, I am sure, can recall similar problems that have confronted him from time to time in his department at the University of Illinois.

Pertaining to the essayist's description of the structural arrangement of the neck, we are not in full agreement. In a paper appearing in the Annals of Otolaryngology (March 1956) is presented our conception of the surgical anatomy of the neck. We hope that Dr. Proctor, after study of this article, may alter his views. At all times surgical exposure of the neck should be very adequate. This will facilitate proper identification of important structures and thus be a great factor in avoidance of their accidental injury.

DR. PAUL H. HOLINGER: This excellent discussion Dr. Proctor has given is important to us aside from its scientific value. It stresses the fact that Dr. Snitman and Dr. Lederer have emphasized for many years, that the neck is the field of the modern otolaryngologist. In this area he is best equipped to reach a diagnosis and carry out therapy. It would seem more plausible to insist on a two-year training in laryngology before a general surgeon is considered qualified to treat many of the cervical lesions, rather than to demand that an otolaryngologist must have a two-year surgical training in lesions below the diaphragm. In the departmentalization of the body through specialization, Dr. Proctor has clearly demonstrated the importance of a laryngological background in the management of problems of the cervical region.

DR. BRUCE PROCTOR (closing): I wish to thank Dr. Snitman for his criticism. There is one thing about neck surgery that I would like to emphasize. One cannot be too positive about the preoperative diagnosis. You think you have a cyst and wind up with a tumor. One must be prepared to modify his approach and follow the pathology, wherever in the neck it may be.

Meeting of Monday, March 5, 1956

THE PRESIDENT, DR. PAUL H. HOLINGER, IN THE CHAIR

The Predictability of Hearing Loss in Acoustic Trauma

JAMES F. JERGER, PH.D.

RAYMOND CARHART, PH.D.

(Abstract)

In an attempt to find a workable method for predicting individual susceptibility to acoustic trauma, various aspects of the ear's reaction to temporary acoustic stress were explored. Evaluations of a number of possible techniques led to the development of a method based on the temporary threshold shift after brief stimulation. This method measures the amount of time required for the threshold at 4500 cps to return to within 20 db and to within 10 db of its prefatigue level after a 60 second stimulation by a 3000 cps tone at an SPL of 100 db.

In an effort to establish the validity of this method as an index of noise-susceptibility, the test was administered to 199 trainees at the USAF Jet Mechanics' School, Amarillo, Texas, just prior to their exposure to high-level jet engine noise over a three-day period.

Hearing loss, as a result of the exposure to jet-engine noise, was taken as the difference between the pre-exposure audiogram and a second audiogram obtained eight weeks after the trainees' removal from the noise environment.

The brief noise-exposure period was not sufficient to produce substantial hearing loss in any trainee. However, a definite relationship was noted between the measures of recovery time obtained prior to the jet-noise-exposure period and the subsequent development of relatively mild impairment in the 3000-4000 cps region.

Although these results must be interpreted with extreme caution, they suggest that susceptibility to permanent hearing loss can ultimately be predicted by measuring an ear's reaction to a temporary, and relatively minor, acoustic stress.

DISCUSSION

DR. HENRY B. PERLMAN: Drs. Carhart and Jerger have carried out a carefully planned investigation designed to relate the degree of temporary threshold shift after a one-minute exposure to 3000 at 100 db with the degree of hearing loss ten weeks after exposure to jet engine noise for 12 hours. This was for the purpose of discovering if there are noise susceptible people and if they can be separated from the others by tests.

They have obtained some suggestive evidence that the subjects having the most severe loss after a short fatiguing test tone measured as time in seconds to return to 20 and 10 db of pre-test level showed the greatest losses after exposure to jet engine noise. However, the maximum loss of 10 db or more was found in only 18 out of 345 ears. These appeared to take an average of 16 seconds longer to return to within 10 db of the pre-fatigued threshold. Current studies of workers in noise are being carried out under the auspices of the Committee on Noise of the Academy, in order to throw light on susceptibility and recovery period. Some of you may recall the demonstration of industrial noise given by Dr. Glorig at the last Academy meeting. When one considers the extreme noise levels that prevail in certain industrial and military operations and the relatively

small difference in the response of the least and most susceptible individuals in this group tested by Drs. Jerger and Carhart, it would be unlikely that a sufficient resistance to noise is present in some normal hearing persons to permit them to work months and years in this noise without loss of hearing.

Physiologically the normal auditory end organ and its neural apparatus is likely to be pretty regularly susceptible to damage under great stimulation. Although Ruedi believes that vitamin A has a protective effect against acoustic trauma, there is little or no evidence to suggest important differences in the overload response of a normal ear. On the other hand, changes in the function of the middle ear muscles might explain differences in the amount of acoustic energy reaching the cochlea without affecting the threshold. Experimentally it is easier to damage the organ of Corti when the protective function of the middle ear muscles is temporarily removed by general anesthesia. A report on a patient with paralysis of the stapedius muscle which I made some time ago includes the differences in recovery between the normal and the affected ear to a 2000 cycle tone at 100 db for two minutes. The threshold was normal in each ear. The functional reactivity of the middle ear muscles to over-threshold sounds may change slightly from person to person and from day to day.

There is widespread interest in the problem of acoustic trauma. The interested parties are now aware that this problem exists and, in good faith with medical consultation, they should be able to work out practical solutions. Pre-employment audiograms are useful as well as tests after an initial short period of work. The noise produced by jets with after burners is particularly dangerous. Recent efforts to reduce this noise have been partly successful but at the sacrifice of thrust. The noise about jet engine test cells can be reduced, and this points up the fact that isolation and reduction of noise or changing the operation, i.e., from riveting to welding, can sometimes be a practical answer. Where exposure to high noise level is inevitable, ear defenders, use of conduction or totally deafened people, shortened exposure time and hearing tests are worth while.

I should like to know what was the sound level and frequency spectrum of the jet noise at the point where the subject was stationed. Also, what maximum time limit may be necessary to observe all the recovery that will occur after exposure.

DR. SHERMAN SHAPIRO: In this State the situation is not the same as in New York and Wisconsin, for the simple reason that partial

hearing losses are not compensable here. In New York they had an acute problem because partial losses were compensated. This makes it more difficult to review this paper from a practical standpoint because, generally speaking, employers are not interested except as the matter affects their pocketbook. Most people who work in noise over a number of years lose a good deal of hearing but are not rendered totally deaf. From what practical contact I have had with such people I should say the problem is complex. There are individuals who have been deafened by several hours' exposure to an air hammer in a closed space, yet others have worked with air hammers for years without harm. I believe the state of the stapedius muscle may be an important factor.

This is a very good approach. It is certainly an end to which we must strive to try to develop some test. One factor which makes it more difficult is the variation in damaging sounds. Explosive sounds like drop forge hammers are much more harmful than steady noises. I do not know that a single test can be defined to cover all conditions, but let us hope that something will be accomplished.

DR. RAYMOND CARHART: The approximate noise level used was about 140 db. As for how long it took for full recovery from noises of that type, we did not have any way of knowing.

Management of Fractures and Soft Tissue Injuries About the Face

JOHN B. ERICH, M.D.

ROCHESTER, MINN.

(Abstract)

If satisfactory cosmetic results in the treatment of facial injuries are to be obtained, the following factors should be emphasized: Early treatment and proper debridement of facial lacerations, complete hemostasis, use of fine skin suture material and pressure dressings. Much unnecessary scarring and disfigurement of the face could be prevented by the immediate application of free skin grafts to regions denuded of skin. In the management of fractured facial bones, immediate treatment is not so important; of more significance is careful preoperative planning.

DISCUSSION

DR. G. KENNETH LEWIS, Chicago: When the subject of facial injuries comes up, the various material and gadgets used for the alignment of the fractures of the middle third of the face and the instrumentarium required, recalls an incident during World War II when I was ordered to take over a plastic center. Everyone was worried because of lack of proper equipment to work with. I knew a Sergeant named Thall and knew his ability to acquire property and necessary supplies. I knew he would have a crowbar, a pair of pliers, a hammer, a screwdriver and some hairpins. Casualties were scheduled to arrive sometime during the night, so Thall and I went out to requisition wire, instruments, tools, suction machine, etc. When the patients arrived their immediate needs were taken care of and the fractures were reduced the following morning. The wounds were cared for and no difficulty was encountered. What I wish to convey is that all the gadgets, splints and apparatus commonly associated with this surgery are nice to have, but just as good results can be obtained by improvisation. For buccal arch bars, we stripped the rubber off No. 14 and No. 16 electric wires; some brooms were minus the usual wire about the handles; some tool shops were minus wire cutters and pliers; the x-ray department lost some valuable lead plate; the orthopedic service donated, unknowingly, plaster, etc. The material that was improvised served admirably until the medical supply was able to furnish us the usual material and equipment, and the results were no different.

The picture Dr. Erich showed with dirt in the tissues points to one of the most important points in the care of fractures in which soft tissue has been opened to the outside, and dirt and debris of all sorts has been incorporated into the tissues. Dr. Erich mentions hydrogen pyroxide; I use soap and water and a vegetable brush. This works well, is always available and saves a tremendous amount of tattooing in the tissues, which it is impossible to remove later except by cutting the tattoo out piece by piece. In nasal reconstruction I have found cancellous bone to be superior to cartilage because of the tendency of the latter to curl, which leaves a deformity which is displeasing to the patient and embarrassing to the doctor. If cancellous bone is absorbed it is replaced by fibrous tissue which takes on the character of normal cartilage so far as resilience, movement and feeling of normal cartilage are concerned. I have discontinued the use of prepared cartilage and foreign material; when I used it, the cartilage would stay in place for a year or two and eventually erode through the skin and had to be removed.

Treatment of wound edges is most important, and if the laceration is approximated with untraumatized skin, there will be a minimal amount of scarring. The edges of the wound should be pared back to the normal skin edges, and the use of a number of sutures for the apposition of the edges is necessary. The stitches should be as fine as possible, and to prevent stitch scars they should be removed at the earliest possible date, usually within 48 to 96 hours.

In x-ray diagnosis of fractures of the face, five views will demonstrate practically all the fractures plus the degree of dislocation. These are the Waters position, the normal occipital mental projection. This demonstrates the frontal sinuses, the orbits, the great wings of the sphenoid, the malar bone, the antrum, the zygomatic arches and the coronoid processes. The second position is the normal 30° rotated lateral projection, which demonstrates the hyoid bone, inferior dental canal and the vertebrae, and will necessitate a right and left view. A straight lateral position shows the profile of the upper jaw and the facial bone. Lastly, the postero-anterior position for demonstration of the ramus of the mandible and the condyle. There may be specific fractures which require a special view, but these can be obtained at a later period after the scout pictures have been read. Ordinarily when called to see a patient with a fracture of the face, we find many pictures have been taken and many plates made, none of which show what we are looking for. It is slightly embarrassing at times to suggest that additional x-rays are necessary to determine the dislocation and the type of fracture.

DR. JOHN B. ERICH (closing): I would like to mention that the method I have outlined may not correspond with what you use, and if your method works, certainly I would not change it. My associates occasionally want me to try something else, but I prefer to stick to the method I am used to.

Meeting of Monday, April 2, 1956

THE PRESIDENT, DR. PAUL H. HOLINGER, IN THE CHAIR

Intranasal Chondrosarcoma: A Supplemental Case Report

LAWRENCE J. LAWSON, M.D.

(Abstract)

A chondrosarcoma is a tumor rarely found intranasally. The primary type arises from the perichondrium and occurs in young

individuals, developing metastases and extensions into the veins. The more common secondary type arises from cartilage rests and is nearly always seen in adults. The diagnosis of chondrosarcoma should be based on both histologic and clinical features.

A case is reported with necropsy findings of chondrosarcoma originating in the nasal septum and secondarily invading all paranasal sinuses with a known duration of fifteen years. When compared with other records, this duration would seem to indicate that with increasing age there is a corresponding decrease in rate of growth of the tumor.

It is the opinion of the author that even though there was terminal disfigurement and blindness, the management outlined was preferable to the gross dysfunction and disfigurement that total elimination of this tumor would have required when the sinuses were first surgically investigated.

Dolophine hydrochloride in 5 milligram tablets is of superior value in decreasing discomfort in the terminal months.

Chondroma and chondrosarcoma are known to be resistant to radiation. In spite of this fact, expertly directed radiation therapy is of considerable help in the management of this difficult problem.

DISCUSSION

DR. BURTON SOBOROFF: It is of interest to hear the final follow-up of the rather thorough coverage of this case over the years. The x-rays of this patient and ours are almost identical, although Dr. Lawson's patient was twice as old as ours. The lesion is progressive, and although he indicates that conservative treatment is best, that might apply to an individual of that age and not to one who is younger. On the other hand, if a tumor is found somewhat smaller and relatively limited, it would be my opinion, having followed these cases, that the best approach would be wide exposure by the Ferguson technique, splitting the lip, exposing the cavity and excising the antrum region. No other therapy seems to be effective, and these tumors go on to invade the optic chiasm and extend to the brain, with ultimate death.

In our case the pathologist called it chondroma and said it was hard to determine whether it was chondroma or chondrosarcoma, and that it should be watched very carefully. In the head region

it makes little difference, because the tumor is malignant by its location and by the nature of the cells themselves. We feel that exploration and widespread excision should be done. In the management of chondrosarcoma elsewhere in the body, some value has been found in x-ray therapy, although in the head it would seem to be of limited help.

DR. LAWRENCE J. LAWSON (closing): I have carefully checked the wording of the paper. By conservative treatment I meant to limit conservatism specifically to this case, inasmuch as it was far advanced when first seen in our clinic. Certainly the surgeon should eliminate tumor tissue thoroughly and with safe margin when opportunity is afforded. In retrospect, we might wish that a more complete removal of the bony nasal septum had been done when the tumor was originally removed. This was the only opportunity to obtain a cure. Drs. Soboroff and Lederer were able to obtain some very excellent kodachrome slides demonstrating the pathology in their patient. We did not have intracranial pathology to demonstrate, therefore our lantern demonstration is limited to serial x-ray studies.

We should emphasize the fact that x-ray therapy is of limited value. It does retard peripheral growth.

Odontopathic Aspects of Otolaryngology

H. SINGH, M.D.

R. KOWAL, M.D.

R. H. BORKENHAGEN, M.D.

(Abstract)

Many patients present themselves to the otolaryngologist with problems that have as their source dental structures. Facial pain often presents a perplexing problem to the physician as well as the patient. Inflammation of the soft tissues of the tooth, known as a pulpitis, may be the source of vague facial pain. Pain referred to the ear may be from a mandibular tooth, while pain in the eye or upper part of the face is sometimes from an upper tooth. Traumatic occlusion or a high spot on a filling may cause pain. As inflammation in the pulp of a tooth continues, necrosis takes place, and infection spreads into the surrounding soft tissues of the jaws.

Postextraction osteitis, or "dry socket" occasionally develops after removal of a tooth. This painful condition is usually self-limiting in about fourteen days, and is treated by cleansing the alveolar socket and applying an antiseptic and anesthetic ointment. Impacted teeth may cause vague pain, and adequate intraoral and extraoral jaw films are needed for diagnosis. Inflammatory, traumatic and degenerative diseases of the temporomandibular joint must be considered in pain of the facial region. Placing the jaw at rest is necessary, and any treatment is based upon eliminating or controlling the cause.

Pericoronitis, or inflammation of the soft tissue overlying a partially erupted third molar causes severe pain. At times major complications develop, including pterygomandibular, infratemporal, parapharyngeal, parotid and submaxillary abscess. Incision and drainage, based upon an understanding of the anatomy involved, is the treatment of choice in these extensive infections.

Oroantral fistula may be related to loss of a tooth or root into the maxillary sinus. The condition of the sinus must be favorable to obtain a successful closure of the fistula. Palatal or buccal flaps are used for closure. Facial trauma presents many problems involving odontogenic structures. Maintenance of an adequate airway, prevention of aspiration of foreign bodies, and the prompt reduction of certain fractures is important. Function of the jaws is closely related to the occlusion of the teeth, and an appreciation of occlusion is desirable. Injudicious removal of a tooth in the line of fracture and blood in the ear canal associated with condylar fractures can produce unfavorable sequelae if not carefully considered.

Cysts and benign tumors of odontogenic origin are often seen by the otolaryngologist. Cysts may be of odontogenic ectodermal or periodontal type. The ectodermal type include primordial, dentigerous and multilocular ones. The periodontal ones are classified as periapical and parietal. Cysts are important because of their slowly expanding nature. Much bone loss may occur unless they are recognized and treated properly. Benign tumors include fibromas, peripheral giant cell tumor and osteogenic types, such as the torus maxillaris and mandibularis.

The discussion presented is merely an introduction to that portion of medical science which the otolaryngologist finds necessary to evaluate and correlate with his own problems.

DISCUSSION

DR. WALTER WM. DALITSCH: These essays have been so complete and thorough that to discuss them properly would take quite a long time. It is rather unique to present such a program to an otological society, and I think you are to be commended on your interest in the subject.

Dr. Kowal mentioned pain as being related to odontographic disorders. Pain has always been associated with dentistry. Certainly one of the greatest boons to be desired is painless dentistry. The control or the abolishment of pain has always been in the minds of dentists, and it is to their credit that they have attempted to control and abolish pain. Wells and Morton both undertook their work in anesthesia in the effort to relieve pain, with nitrous oxide and ether. Fischer and Braun did the early work in local anesthesia with procaine.

I think we can differentiate big pain and little pain. Sometimes when the big or excruciating pain is removed, a patient may find there is still a small pain that bothers him. For the higher levels of pain some of the newer relaxants may be applied. Dentists have been among the first to use hypnosis to alleviate the tension and anxiety factors of pain. There is still a strong need for looking for and eliminating dental and rhinologic pathology in tic doloreaux. Inflamed and infected pulps, infected gums or bone, impacted teeth in close proximity to the mandibular nerve can be forerunners of the tic doloreaux syndrome.

The surgical considerations of sepsis and abscess were well discussed. I think we should attempt to differentiate the bacteriologic aspects. We may have histiolytic and hemolytic types of bacteria, and then there may be spread of infection with tissue destruction and diffuse cellulitis, and without regard to fascial planes.

Stomatitis is important. It always makes me shudder to see a patient with Vincent's stomatitis being subjected to a general anesthetic. Tracheal intubation, bronchoscopy and esophagoscopy through a septic mouth may lead to aspiration and lung infection.

I should like to mention focal infection. It is an important consideration in many cases, because patients will not get well until it is eliminated.

Regarding the topic of cysts; many bone cysts are silent and only discovered by x-ray. We have found at Great Lakes a great number

of large cysts at the apices of teeth, with no symptoms, where the pulp had died under a filling. Routine and periodic dental x-rays should be made to disclose such hidden pathology. Multilocular cysts are interesting. Adamantinoma or ameloblastoma are somewhat confusing in pathology and in clinical course. They are not truly malignant but they are locally persistent. They do not spread to the regional nodes and they do not produce distant metastases. Some believe in first decompressing the tumor and later removing it locally; others believe that radical removal with mandibulectomy should be carried out. I think that thorough local excision should be attempted, and if there is local recurrence a second attempt at eradication can be tried. Many times there are years of comfort and freedom from symptoms.

We can readily appreciate that there is a close relationship between the teeth and the rest of the body, especially the head and neck. The functions of respiration and speech and deglutition are all closely related to the oral structures. Yet there is often a wide gap between medicine and dentistry in their aims and in their results. Up to 1848 dentistry was not a separate profession. Dentists went to medical school, but in 1848 a group seceded from the University of Baltimore to found a college of dentistry and for more than 100 years each profession went its separate way, in clinical practice and research. The body has been divided into separate compartments with rigid boundaries which must not be trespassed. A different language is spoken by each profession.

In treating certain lesions which require understanding between physician and dentist, the patient often does not receive adequate treatment. I think this has been recognized by dental faculties and they are trying to give their students a more complete knowledge of basic sciences and fundamental concepts of medicine, but I do not think that medical students have had the same training in the recognition and care of dental disease. In the 1900's in the organization of the American Medical Association, there was a section on stomatology, but for some reason this was abolished, and again a wide gap was left. Many dentists have felt the need of more complete training and have secured their M.D. degree. Many of these double degree doctors have taken up plastic surgery, others general surgery. A large number of these men have formed a Society of Maxillofacial Surgery. Others, like our essayists, lead toward an otolaryngological environment. This indicates a trend toward regional specialization which seems logical.

DR. G. H. MUNDT: I put a very high value on the discussion of a difficult subject. For many years I have been interested in concomitant oral and nasal defects, the general formation of the palate and dental occlusion. These are of great importance to a patient's welfare. The indiscriminate extraction of teeth frequently has a definite bearing on the individual's ability to breathe satisfactorily. A change of bite frequently disturbs the patient, and in the majority of cases the patient does not realize what is causing his difficulty.

It is certainly true that if an individual is to have satisfactory nasal breathing he must be able to close his mouth in repose. If he cannot do so, no intranasal surgery will establish proper nasal respiration.

DR. FRANCIS LEDERER: I would like to comment with justifiable pride on my part and I am sure of all of you, on this mode of presentation. I am sure these gentlemen have only scratched the surface. This "courting period" between dentistry and otolaryngology is very interesting and we hope it will continue for some time. I have never been satisfied with the fact that dental students had to dissect a leg, and medical students never even learned how many teeth there were in the mouth. Dr. Dalitsch is right in saying that medical students could use this additional knowledge.

What has been presented tonight is only the beginning. If you were in contact with these men you would find great interest in a working arrangement between these specialists. They find themselves working in harmony, and dental residents in training and medical residents as well will profit by it. It speaks well for the future development of dental medicine.

ISAAC HAMPSHUR JONES, M.A., M.D.

1881-1956

Isaac Jones, pioneer in aviation medicine and neuro-otology, born in Philadelphia 1881, was graduated from the University of Pennsylvania Medical School in 1906.

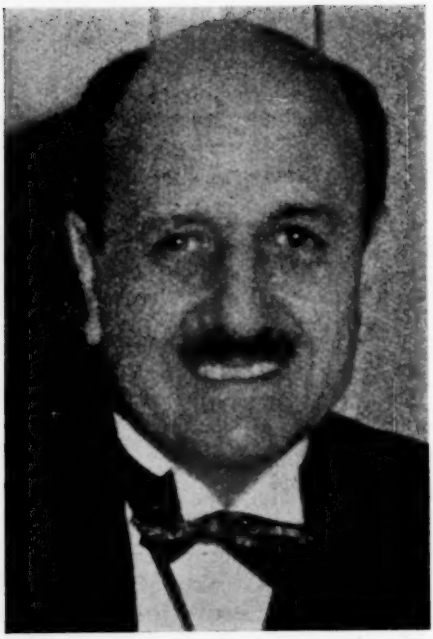
Soon after graduation he became interested in the researches of Dr. Robert Barany of Vienna, which had opened a whole new field for the investigation of the internal ear in relation to equilibrium and vertigo. After studying with Dr. Barany, this research was continued in this country through a new department of neuro-otology in the University of Pennsylvania which was established for that purpose under the direction of Dr. Lewis Fisher, Dr. Seth Brumm and Isaac Jones.

In 1916 during a meeting of the Academy of Medicine in Washington, D.C., he delivered a lecture on the subject of the ear and aviation. Here he formed an acquaintance with Dr. Theodore Lister who brought specialization into the Army Medical Corps and created the service which was later to become known as aviation medicine when the U.S.A. entered World War I.

Dr. Isaac Jones, otologist, and Theodore Lister, ophthalmologist, were authorized by Surgeon General Gorgas to establish the minimum requirements for which aviators must qualify before being admitted to training. This examination changed the selection of pilots from chaos and chance to a scientific determination of adaptability. After this, the pilot was no longer a fatigued infantry man assigned to aviation because he was expendable, but a physically and mentally equipped individual for combat.

Isaac Jones was appointed to the American Delegation at the Versailles Peace Treaty and to the committee which drafted the international requirements for commercial aviation. For this and other services the French government made him Chevalier of the Legion of Honor.

In 1918 his text entitled "Equilibrium and Vertigo" was published. This was to become the standard reference work for students of medicine and for all those interested in the investigation of the inner ear including the aviation section of the Signal Corps of the U. S. Army.



ISAAC H. JONES

In 1920 Doctors Isaac Jones, Samuel Ingham, and Eugene Lewis formed a group in Los Angeles for the practice of ophthalmology and otolaryngology. It became famous as a head clinic especially for conditions involving disorders of the eye and ear with their central connections.

Shortly after arriving in Los Angeles, Dr. Jones formed an association with Dr. Vern Knudsen, Professor of Physics in the University of California at Los Angeles. Their common interest in acoustics resulted in the production of an experimental hearing aid and the most advanced audiometer of that period.

Isaac Jones was never wholly content with his practice. There was an inner compulsion which broadened the horizon and expanded the activities of his profession and his community. Two of his activities deserve special mention. One is the great Southwest Tennis Association which he founded. Annually the stars of the tennis world compete for honors and young talent is sponsored by that organization. The other is the now famous mid-winter study course for the combined specialty of otolaryngology and ophthalmology which he also founded. Here during the last two weeks of January, lectures in otolaryngology have been scheduled since 1928. Foremost authorities of the world have been brought to Los Angeles each year to teach a student body which enrolls from all areas of the country.

The last publication of Isaac Jones is entitled "Flying Vistas." It is the story of the flight surgeon and the progress of aviation. The material and style of this book make excellent reading for either a specialized or a general reading public.

It is impossible to fully realize the value and influence of Dr. Isaac Jones. The best tribute to any man is to tell what he has accomplished in his life. It is certain that many pilots are alive today because this man established the requirements for their responsibilities and safety. It is certain that his recommendations and training program increased the efficiency of the Air Corps in time to be realized before the end of World War I when our pilots proved to be the best in all the world. Commercial aviation adopted his program as soon as it was incorporated on a large scale. These are legacies which have come to all of us because this man lived.

Isaac Jones died on September 9, 1956. His survivors are Dr. Samuel Austin Jones, a prominent surgeon of Los Angeles, and two grandchildren, Cecile and Mary Ann.

D. H.

Abstracts of Current Articles

EAR

The Effects of the Tympanic Muscle Reflexes upon Sound Transmission.

Wever, E. G., and Vernon, J. A. Acta Otolaryngol. 45:5 (Sept.-Oct.) 1955.

Carefully controlled experimental studies were carried out upon a series of 15 cats to show the changes in sound transmission resulting from reflex contraction of the tensor tympani and stapedius muscles, acting jointly and individually. The effect of stimulation of reflex contractions is most evident in the reduction in transmission of low tones, below 600 cycles, the amount of reduction increasing with the intensity of stimulation. The tensor tympani alone produced moderate reduction in the frequencies 900 to 1500. The stapedius apparently has little effect in this higher range. The regulatory effect of these muscle reflexes may be 20 db for the lower tones.

This excellent article provides sound evidence of the validity of the "protective theory" of the physiology of the tympanic muscles.

HILL

Cupulometric Studies on the Pigeon.

Ascher, G., and Stabile, J. Acta Otolaryngol. 46:2 (Mar.-Apr.) 1956.

This study was undertaken to compare the reactions of the ampullae of the horizontal and vertical semicircular canals of the pigeon to rotatory stimuli. Nystagmus was recorded with the aid of a narrow-slip photo-electric cell connected with a direct-writing electrocardiograph, using a light aluminum foil sheet fixed to a cap on the pigeon's head and illuminated from above. This allowed the shadow of the bird's head, varying with the nystagmoid movements, to be thrown on the photo-electric slit. It was found that the duration of the nystagmus and the number of beats was greater from the horizontal canals than from the vertical. Phylogenetic and anatomical reasons were considered to be responsible for these differences.

HILL

Auditory Fatigue and White Noise. An Attempt at Working Out a Predictive Test.

Christiensen, E. Acta Otolaryngol. 46:2 (Mar.-Apr.) 1956.

Forty-one persons with normal ears were subjected to white noise at 4000 cps and 105 db for three minutes, following which the threshold shift and the recovery time were measured. Subjects showing a threshold shift of 25 or more db, one-half minute after cessation of the noise, and 15 or more db, 15 minutes after cessation, and a recovery time of greater than 15 minutes were considered as susceptible to auditory damage.

The small number of subjects tested would make one somewhat dubious of the accuracy of these figures owing to the variation in individual susceptibility to acoustic trauma.

HILL

The Ototoxicity of Neomycin. Experimental Investigation.

Roskver, N., Christensen, E., Petersen, P. V., and Weidman, H. Acta Otolaryngol. 46:2 (Mar.-Apr.) 1956.

In a series of experiments on guinea-pigs it was found the neomycin had a selective effect on the cochlea, completely destroying hearing, while streptomycin, viomycin, and polymyxin had a similar effect on vestibular function. Histological examination of the labyrinths in the animals treated with neomycin revealed atrophy or destruction of the organ of Corti, the cochlear ganglion, and the stria vascularis. Those treated with streptomycin showed only slight degeneration of the vestibular ganglion in a few cases. Histological examination of the central nervous system showed definite changes in the medulla, affecting the acoustic tubercle in those treated with neomycin, and Deiter's nucleus in those having streptomycin. Those treated with viomycin and polymyxin revealed no definite histological changes. Inasmuch as these cases all exhibited definite signs of loss of either cochlear or vestibular function, the morphological findings alone may not indicate the site or severity of the toxic effect of these drugs. Instillation of neomycin into the canal or directly into the middle ear for up to 30 days had no effect upon hearing.

HILL

The Facts of Heredity Deafness in Auditory Training.

Getz, S. B. Acta Otolaryngol. 45:5 (Sept.-Oct.) 1955.

Experience at the California School for the Deaf indicates that children showing the "flat response" audiogram respond better to auditory training, while those with the typical perception deafness curve (above 500 cycles) might be benefitted by the use of hearing aids. If this could be determined before the age of reliable audiometric testing it might be possible to predict the results of auditory training. In an endeavor to ascertain if there was a typical curve for hereditary deafness, the audiograms of 21 children from five families in which both parents were deaf, were studied with negative results. Knowledge that a child's deafness is probably of hereditary origin is of little use in predicting the value of auditory training, although this is indicated in these cases.

HILL

A Case of Tetanus Auricularis.

Jelnes, K. Acta Otolaryngol. 45:5 (Sept.-Oct.) 1955.

This is a report of a case of chronic tetanus cephalicus originating in a discharging radical mastoid cavity, apparently from scratching the ear by the patient. The diagnosis was verified by the bacteriological findings and by the response to therapy.

HILL

NOSE

Possible Access by Way of the Maxillary Sinus in Surgery of the Lacrimonasal Passages.

Lopez, J. S., and Avelliera, C. N. An. Oto-Rino-Laringol. Uruguay 25:4:169-178, 1955.

Dacryorhinocystostomy is unsuccessful in approximately 20 per cent of cases. Resection of the infected sac is equally unsatisfactory. A more effective method consists in detachment of the lacrimonasal canal to afford direct access by a shorter route to the anterior ethmoid cavities and enter the external portion of the ethmoid segment, by the method used in the surgical treatment of chronic pansinusitis.

In ascending infection of the lacrimal passages, the mucosa of the lower portion which is profusely vascularized becomes swollen, hypertrophic and inflamed. To afford direct access and treatment, the maxillary sinus is penetrated through the anterior wall of the orbital prolongation of the antrum. A chisel and a gouge forceps are employed to resect the lower portion of the bony wall between the sinus and the nasal passage. The penetration is continued upward through the canal as far as the upper and inner margin of the antrum. Thus the membrane of the lacrimonasal canal is uncovered along its entire length. A U-shaped incision, open at the top, is made in the nasal mucosa, following the external wall of the lower meatus and the contour of the bone. The pedicle above the flap of secreting mucosa coincides with the slightly oblique downward and backward plane which passes through the line of insertion of the lower turbinate. This flap of mucosa is raised with forceps, exposing the lower meatus, near the orifice of the lacrimonasal canal. The lower lip of the orifice, above the line of insertion of the lower turbinate, is incised. A scalpel is used to join the anterior and posterior ends of the U-shaped incision in the nasosinusal flap, completely disengaging the canal, which can be readily separated from the bony wall with a thin spatula inserted upward along the posterior inner wall of the lacrimal passage.

The subsequent procedure to restore permeability depends upon the condition of the canal: 1) simple isolation of the canal, followed by irrigation and removal of mucus and pus, 2) catheterization in both directions, longitudinal resection of the stenosed segment of the canal and the insertion of a polyethylene tube to ensure drainage; 3) isolation, total extirpation of the sac and insertion of the polyethylene tube which is attached at the top to the orbital margin and opens into the nasal fossa below. The tube is left in place, and is well tolerated. The mucosal flap is then resected.

This method is simple, leaves no lacerations and affords direct access to the lower and less visible section of the lacrimal passages, which is most liable to stenosis, due to the vicinity of the infected secreting mucosa to the profuse vascularization, with the danger of obstructive ectasis, and to the swelling of the mucosal folds. There are no visible scars. Drainage is by the normal nasal route.

HIGBEE

A Case of Fronto-ethmoid Osteoma.

De Villasante, J. Portella. Acta Oto-Rino-Laringol. Ibero-Amer. 7:2:143-165, 1956.

The initial symptoms were persistent vomiting for two months, followed by pain in the right supraorbital region, and vertigo. The diagnosis was frontal sinusitis. However, surgical intervention afforded no relief. Two months later the patient complained of heaviness of the head, pain and nausea. There was slight outward deviation of the right eye-ball, but no diplopia or other visual disturbance and mobility of the eye-ball was normal. On rhinoscopy the right side appeared normal, but the left side was filled with mucopurulent fetid secretion, the mucous membranes were markedly hypertrophic and violet in color.

Transillumination and roentgenographic examination showed a dense shadow in the right frontal sinus, suggesting osteoma, and a diffuse clouding in the left maxilloethmoid sinus indicative of suppurative sinusitis.

Trepanation of the right frontal sinus revealed as osteoma filling three-fourths of the cavity, and completely obstructing the nasofrontal canal. It was not adherent, and was readily extirpated. The intersinusal septum was normal. A projection visible on the first roentgenogram was probably a small osteoma pedicle which was removed during the surgical exploration. It might otherwise have resulted in a secondary tumor. Following drainage and local treatment with penicillin, the operative wound was closed.

The second stage of the intervention was a Caldwell-Luc operation on the left maxillary sinus. The cavity was filled with a creamy fetid pus, the walls were greatly swollen and covered with polyps. The mucosa and the left ethmoid labyrinth were curetted, to form a single cavity. The sinus and labyrinth were thoroughly drained and washed out with penicillin solution. The orifice was widened to facilitate the insertion of drainage gauze and tampons and to allow continued drainage of the secretion. Both operations were carried out under basal and local anesthesia. Following intervention penicillin was given parenterally (200,000 units every four hours for six days). The tampons were removed after 48 hours and the gingival sutures in six days. Aerosol-oxygen treatment was given and a penicillin solution (40,000 units per dose) three times a day for three days.

The purulent secretion from the left sinus contained Staphylococcus pyogenes albus. Specific desensitization was carried out by the

injection and local aerosol application of Manzanete's histobactovaccine and antihistamine.

The symptoms did not recur and recovery was complete. The histologic diagnosis was osteoma eburneum.

The vomiting in this case was probably not due to the osteoma but to the constant swallowing of septic secretion. The pain and deviation of the eye-ball were due to pressure by the osteoma, to toxicity, or to the inflammation of the sinus. The tumor was too small (2 inches) to interfere with vision. It was probably originally adherent, the pedicle having been detached during the first exploration.

Tumors of this type have been variously attributed to: 1) embryologic tissue predispostion aggravated by inflammatory or traumatic factors; 2) local infection, although they may occur in the absence of infection; 3) ossification of polyps; 4) general infections such as syphilis and tuberculosis, although this is improbable; 5) some unknown nutritional or metabolic disturbance.

Small osteomas are sometimes found incidentally during roentgenographic examination for sinusitis. They should always be removed. In unoperated cases the 40 per cent mortality may be due to complications, but there is always danger that the benign tumor may become malignant.

Most of these frontal, ethmoid and maxillary tumors can be readily removed through a frontoethmoid incision. When situated in the sphenoid sinus, they may be inaccessible and intervention is hazardous. Accumulations of pus or mucus are readily removed through the frontoethmoid incision. Osteomas associated with intracranial complications or large growths with signs or extension inward should be removed through a transverse-frontal incision by Cushing's technique. If there is secondary sinus infection, it is advisable to operate in two stages.

HIGBEE

Radiotherapy of Cancer of the Maxillary Sinus.

Leborgne, F. E. An. Oto-Rino-Laringol. 25:4:164-167, 1955.

Roentgenotherapy in these cases can be successfully combined with fenestration of the maxillary sinus by resection of the palatal arch, which permits observation of the lesion and affords a check on its development. This treatment is sometimes followed by "packing"

with radium, or by the implantation of material containing radium tubes in the affected areas. The necrosis which occasionally results can be counteracted by antibiotics. Surgical intervention alone is effective in the case of restricted lesions. However, if the cancer is extensive and inoperable, as is frequently the case, irradiation is an effective palliative. These tumors are radiosensitive. If irradiation with radium, teleradium or x-rays is supplemented by antibiotics, resection of necrotic bone and tissues, and the establishment of proper drainage, cure can be effected in 20 per cent of cases, as determined five years after treatment. In operable cases the percentage of recovery is 40 per cent, in inoperable lesions, 12 per cent.

Cancer of the maxillary gland usually involves the mucosa, and is of the pavement-cell type. Mixed tumors of the salivary gland are slow in developing, but are resistant to irradiation. Lymphatic metastases, if accessible, shall be radically extirpated. Irradiation is a useful palliative measure in these cases, and may be curative in restricted lesions.

HIGBEE

LARYNX

The Technique of Partial Horizontal Laryngectomy. Preliminary Report.

Rebagliatti, H. An. Oto-Rino-Laringol. Uruguay 25:4:159-163, 1955.

Frequently, following partial horizontal laryngectomy, the larynx, deprived of its connections with adjacent tissues, is displaced downward. It is a question whether the vocal changes following operation are due to this displacement, to an increase in the volume of the vibrating vocal area normally formed by the pharynx and the supraglottic portion of the larynx or to changes in the function of the extrinsic muscles of the larynx, which are incised and sutured during operation. Probably all three factors are responsible.

To avoid dropping of the larynx, the author employs a technique which protects the thyrohyoid membrane and the external perichondrium of the larynx and maintains the normal anatomic position of the larynx. A vertical incision is made from 1 cm above the hyoid bone to the cricoid cartilage. To facilitate the operation, the median line of the hyoid bone is incised. The thyroid perichondrium is freed on both sides with a spatula. The junction of the internal perichon-

drium with the thyrohyoid membrane is severed. One blade of the scissors is placed between the external perichondrium and the cartilage, the other behind the thyrohyoid membrane. This procedure leaves the junction of the thyroid membrane with the external perichondrium intact. Forceps are employed to bring the epiglottis into the operative field where it is secured with a needle and catgut to facilitate observation of the interior of the larynx and of the extent of the lesion.

By means of a bistoury or scissors, the lateral margins of the epiglottis are followed downward and the soft tissues are separated as far as the upper border of the thyroid cartilage. Clippers are used to cut the thyroid cartilage, exterior to the lesion, without involving the external perichondrium. The oblique vertical incision extends from the upper border of the thyroid cartilage to slightly above the vocal cords. Another incision is made in the cartilage, running horizontally and parallel to the cords, ending in a third oblique vertical incision to remove the lesion and the affected portion of the larynx.

The incisions are then sutured in three planes: the lowest one in the thyrohyoid membrane and external perichondrium, then the incision in the infrahyoid muscles as far as the raphe, and last the skin incision.

It is possible that this restricted operative field would not be adequate for the removal of extensive lesions. However, the advantages of the method are the maintenance of the normal position of the larynx, the integrity of the infrahyoid musculature and of its motor innervation, and therefore of its function and the avoidance of postoperative interference with swallowing.

HIGBEE

Metastases in Cancer of the Larynx.

Alonso, J. M., and Matteo, A. An. Oto-Rino-Laringol. Uruguay 25:4:120-133, 1955.

These cancers have three periods of development, the local stage, the regional lymphatic invasion and the period of extension to distant organs or tissues not in direct relation to the primary focus. The tumor metastasizes by way of the lymphatic system, by direct embolism, by cancerous lymphangitis, or by diversion of the lymph blocked by the affected nodes and invasion of new lymphatic and circulatory

channels, either arterial or venous. Epitheliomas metastasize by the lymphatic route, sarcomas by way of the blood, carcinomas by either pathway.

Some metastases do not cause symptoms, and are discovered only at autopsy. Metastases may appear in distant tissues or organs after the primary cancer has been removed or clinically cured.

Of thirteen cases of pulmonary metastases observed, six appeared within a year and a half after the removal of the primary cancer. In half of these cases local metastases in other regions had occurred.

Metastases to the mouth, esophagus, skin, abdominal organs, eye and brain appeared both when the primary lesion was clinically cured and when it was still active or had recurred. In general, in twenty-five cases studied, the delayed metastases (appearing one and a half to fifteen years later) occurred when the primary lesion was clinically cured. In most cases, except those affecting the lungs, the primary and secondary lesions were malpighian epitheliomas. In a few very late cases there was the possibility of a new localization in individuals predisposed to epithelioma.

In cases in which the primary localization was in the epiglottis, the vestibule or false cords, forty-one late metastases to distant regions occurred. Cancer of the hypoglottis metastasized in fourteen cases; those of the vocal cords and glottis in twelve.

In cancer of the larynx, most metastases affect the cervical lymph nodes. Tumors made up of embryonal undifferentiated cell tissue result in most metastases. The latter are sometimes well defined, sometimes irregular or multiple, depending upon the location, and upon complications such as necrosis, edema, sclerosis, etc. In general, the tumors are hard, infiltrating, irregular, yellowish white and granular on the surface. Others are friable and also involve the muscular and venous tissue. The arterioles and nerve fibers are rarely affected.

Careful pathologic examination of the secondary lesion is essential. Tuberculosis of the lymph-nodes may occur following removal of cancer of the larynx, and the condition may be mistaken for a cancerous metastasis.

HIGBEE

Olfaction in Laryngectomized Patients.

Marco, J., Morera, H., and Gemenez, J. A. Acta Otolaryngol. 46:2 (Mar-Apr.) 1956.

Forty-four patients who had undergone laryngectomy were studied in an effort to determine the mechanism of hematogenic olfaction. Nasal olfaction was examined by the Elsberg technique, using the essences of coffee, orange blossoms, and lavender, as well as ammonia. For the hematogenic route, a hydro-alcoholic solution of essence of lavender was employed. In order to compare taste and olfaction, the former was tested by using quinine, sodium chloride, sugar, and hydrochloric acid solutions. Histological studies, carried out by biopsy of nasal mucosa at the level of the inferior turbinate, revealed changes "purely of quality" with atrophic changes and infiltrating edema.

Acknowledging the incomplete understanding of all the various factors involved in olfaction, the studies suggest the possibility that "stimulation of the first cranial nerve by the hematic route is associated with direct stimulation of the olfactory centers."

HILL

MISCELLANEOUS

Operative Technique in Sublingual Ranula.

Rius, M. An. Oto-Rino-Laringol. Uruguay 25:4:153-156, 1955.

Ranula is a salivary retention cyst originating in the mucous glands of the mouth and is sometimes due to obstruction of small salivary ducts connected with the sublingual or submaxillary glands or to embryonic impaction. It may occur in the floor of the mouth, usually at the base of the tongue or occasionally in the throat, in the submaxillary or carotid region or in the posterior wall of the pharynx. The patient has difficulty in speaking, masticating and swallowing.

The usual sublingual type is smooth, regular, painless, fluctuating, unilateral and transparent or yellowish. It exerts upward pressure on the floor of the mouth, raising it somewhat. Histologically the wall of the tumor is made up of a layer of cuboid or embryonal epithelial pavement cells, which are found and profusely vascularized as in multilocular cysts. In other cases there is only a thin layer of fibrous tissue without any epithelium. The mucoid content of the cyst is thick, resembles egg-white, is viscous and ptyalin is absent.

These cysts must be distinguished from dermoid cysts, which are firmer and less transparent and which tend to be centrally located, whereas the ranula is unilateral. Multilocular cysts of the throat, invading the floor of the mouth, must also be excluded in the differential diagnosis.

The ranula is generally separated from Wharton's canal, which runs back of it. It may be adherent to the sublingual gland. If it involves the submaxillary region, a narrow strip on the posterior border of the mylohyoid muscle is affected.

Treatment by the injection of sclerosing medicaments is contraindicated as too dangerous; the same applies to resection. It is best to aspirate the contents of the cyst, cleanse the walls with dry gauze and later with gauze treated with a chloroform-iodine solution. The buccal portion of the cyst wall is then resected. Marsupialization has also been recommended. However, in one case the ranular formed a fistula opening into the floor of the mouth which required frequent dilatation of the orifice, and finally radical extirpation.

The author suggests a new technique which avoids rupture of the thin cyst wall, which might result in a hematoma and infection; the procedure also prevents lesion of Wharton's canal and of the posterior portion of the lingual nerve.

Basal anesthesia is employed with pethidine (demeral) and seconal, followed by local anesthesia of the lingual nerves and maxillary region, by means of pontocain, novocain and adrenalin. The tip of the tongue is anesthetized, and a thread is passed through it and held by an assistant, who exerts traction to hold the tongue in proper position for the intervention. Carefully avoiding the orifice of Wharton's duct, the buccal mucosa is incised near the tongue, as far back as Wharton's caruncle. The lingual muscle is separated from the thin wall of the cyst. The incision is continued beyond the caruncle and snub-nosed scissors are used to detach the inner pole in the median line of the ranula. If it is adherent to the mucosa or if there is a fistula or scar tissue, part of the adjacent sublingual mucosa should be extirpated. Otherwise it is readily detached, without contact with the maxillary or mylohyoid muscles. Clamps may be necessary to effect hemostasis. The wound is closed with interrupted sutures. Postoperative treatment consists of antibiotics, irrigation and mouth washes.

HIGBEE

Delayed Speech Test.

Ewertson, H. W. Acta Otolaryngol. 45:5 (Sept.-Oct.) 1955.

This is an interesting well-written article on the value of the delayed speech test using the tape recorder in determining malingering. The psychogalvanic skin-resistance test may prove useless due to excessive sweating or thickened skin of the subject's fingers. The difficulty of differentiating between malingering and psychogenic deafness is discussed. Several case reports are given. The author concludes that "the delayed speech test" is reliable, reproducible, readily intelligible to laymen and lawyers alike.

HILL

Books Received

A Manual of Oral Surgery. A Step-by-Step Atlas of Operative Techniques.

By W. Harry Archer, B.S., M.A., D.D.S., Professor of Oral Surgery and Anesthesia, School of Dentistry, University of Pittsburgh. Second edition, 877 pp., profusely illustrated, W. B. Saunders Company, Philadelphia, 1956. Price $16.50.

This is a step-by-step atlas of operative techniques in oral surgery. Eleven contributors, in addition to the author, cover the subjects of exodontia, malformations, benign and malignant tumors from the standpoint of diagnosis and treatment. Line drawings outlining steps in operative procedures are excellent and generous in number. The context is good particularly on account of the many case reports included.

Many of the intraoral photographs, particularly of the operative procedures, leave much to be desired because of lack of detail. This is true, also, of many of the radiographs. Emphasis is placed on those conditions encountered by the general dental oral surgeon.

Benign tumors are well described and illustrated. Little space is given to malignant tumors and as in many texts the advanced and not the early lesions are shown. Good photography of a few early lesions, particularly in color, would be a great asset.

JORSTAD

Oral Cancer and Tumors of the Jaws.

By G. S. Sharp, W. K. Bullock and J. W. Hazlet. 561 pp., illustrated, Blakiston Division, McGraw-Hill Book Co. Inc., New York, 1956.

This syllabus for the oral diagnostician is excellent. The authors have attained their purpose in a most creditable manner. They state the purpose of this work is to provide a manual for the recognition of oral cancer, to illustrate with text and photograph the difference between benign and malignant tumors, and to help the general practitioner and dentist arrive at a differential diagnosis of a particular lesion, by inspection and palpation, prior to confirmation by biopsy.

The photographs are good and well chosen. The radiographs are excellent.

The pathologic interpretation of disease entities as encountered in this area of the body is succinctly summarized. Roentgenographic findings in osseous lesions are described in detail.

The authors further state that this work is intended not as a textbook or reference guide in the management of cancer, but is designed as a visual aid in the diagnosis of neoplasms. This has been accomplished.

It is well written and references are generous in number.

JORSTAD

SIXTH INTERNATIONAL CONGRESS OF OTOLARYNGOLOGY

EARLY REGISTRATION

ACCOMMODATIONS HAVE BEEN RESERVED FOR REGISTRANTS IN A NUMBER OF HOTELS IN VARIOUS PRICE RANGES, BUT MAY IS A BUSY MONTH IN WASHINGTON AND THESE CANNOT BE HELD UP TO THE TIME OF THE CONGRESS. THEY WILL BE AVAILABLE ONLY TO REGISTRANTS.

FORMS FOR REQUESTING HOTEL RESERVATIONS HAVE BEEN DISTRIBUTED TO ALL WHO HAVE REGISTERED AS MEMBERS OF THE CONGRESS; THESE SHOULD BE SENT IN AT THE EARLIEST POSSIBLE TIME TO PERMIT OF SATISFACTORY ARRANGEMENTS. OTHERS WISHING TO REGISTER ARE URGED TO COMMUNICATE WITH THE GENERAL SECRETARY, 700 N. MICHIGAN AVENUE, CHICAGO 11, ILLINOIS, U.S.A., AT THEIR EARLY CONVENIENCE. APPLICATIONS FOR HOTEL ACCOMMODATIONS WILL BE SENT AS SOON AS REGISTRATION IS COMPLETED.

PRELIMINARY PROGRAM

SUNDAY, MAY 5, 1957

8:30 a.m.-4:00 p.m.

Registration, Presidential Ballroom, Hotel Statler
Scientific and Technical Exhibits open
Hospitality Lounge for Foreign Members open
Ladies' Committee Hospitality Lounge open

5:00 p.m.

Convocation, Constitution Hall

6:00 p.m.

President's Reception and Buffet Supper, Pan American Union (Informal)

MONDAY, MAY 6

8:30 a.m.-5:00 p.m.

Registration, West Checkroom, Hotel Statler
Exhibits open
Hospitality Lounges open

Open each day during these hours

9:00 a.m.-12:00 noon

Plenary Session, Presidential Ballroom, Hotel Statler

CHRONIC SUPPURATION OF THE TEMPORAL BONE

Openers: Dr. Marcus Diamant, Halmstad, Sweden
Anatomical and Etiological Factors in Chronic Middle Ear Disease

Prof. Luzius Rüedi, Zürich, Switzerland
Pathogenesis and Treatment of Cholesteatoma in Chronic Suppuration of the Temporal Bone

Prof. Horst Wullstein, Würzburg, Germany
Surgical Repair for Improvement of Hearing in Chronic Otitis Media

Discussers: Mr. A. Tumarkin, F.R.C.S., Liverpool, England
Prof. Juan Manuel Tato, Buenos Aires, Arg'ntina
Mr. T. E. Cawthorne, F.R.C.S., London, Eng.
Prof. Fritz Zöllner, Freiburg, Germany

Sightseeing tours in and about Washington (available daily)

MONDAY, MAY 6 (continued)

2:00-5:00 p.m.

General Sessions, 5 simultaneous sections (rooms to be designated)
Film Session, Presidential Ballroom
Sightseeing tours (available daily)
Medical tours to Walter Reed Medical Center
Armed Forces Institute of Pathology
Navy Medical Center, Bethesda, Maryland
National Institutes of Health, Bethesda
Forest Glen Speech and Hearing Center

(These tours available each afternoon)

8:00 p.m.

Reception and tour, National Gallery of Art

TUESDAY, MAY 7

9:00 a.m.-12:00 noon

General Sessions, 5 simultaneous sections
Film Session, Presidential Ballroom
Special all-day program for ladies including tour and luncheon

2:00-5:00 p.m.

General Sessions, 5 simultaneous sections
Film Session, Presidential Ballroom
Special ladies' program continued during afternoon

8:30 p.m.

Concert, Constitution Hall
Program of musical Americana

WEDNESDAY, MAY 8

9:00-9:30 a.m.

Special address, Presidential Ballroom

DOCTORS AS DIPLOMATS

Howard Rusk, M.D., Director, Institute of Physical Medicine and Rehabilitation, New York University-Bellevue Medical Center, New York

9:30 a.m.-12:30 p.m.

Plenary Session, Presidential Ballroom

COLLAGEN DISORDERS OF THE RESPIRATORY TRACT

Openers: PROF. HANS SELYE, Montreal, Canada
Introduction

PROF. MICHELE ARSLAN, Padua, Italy
The Upper Respiratory Tract

DR. LESLIE GAY, Baltimore, Maryland
The Lower Respiratory Tract

Discussers: Sir Victor Negus, London, England
Prof. Branimir Gusic, Zagreb, Yugoslavia
Dr. Aubrey G. Rawlins, San Francisco, California, U.S.A.
Dr. Henry L. Williams, Rochester, Minnesota, U.S.A.

2:00-5:00 p.m.

General Sessions, 5 simultaneous sections
Film Session, Presidential Ballroom

5:00-6:00 p.m.

Business meeting, International Committee (Official Delegates)

6:00-7:00 p.m.

Dinner for Official Delegates and wives, South American Room (formal)

THURSDAY, MAY 9

9:00 a.m.-12:00 noon

General Sessions, 5 simultaneous sections
Film Session, Presidential Ballroom

2:00-5:00 p.m.

General Sessions, 5 simultaneous sections
Film Session, Presidential Ballroom

7:00-8:00 p.m.

Congress cocktail party, Sheraton-Carlton Hotel

8:15 p.m.

Grand Banquet, Presidential Ballroom and Congressional Room, Statler Hotel (formal)

FRIDAY, MAY 10

9:00 a.m.-12:00 noon

Plenary Session, Presidential Ballroom

PAPILLOMA OF THE LARYNX

Openers: PROF. JO ONO, Tokyo, Japan
Etiology

PROF. PLINIO DE MATTOS BARRETTO, Sao Paulo, Brazil
Diagnosis

MR. F.C.W. CAPPS, London, England
Therapy

Discussers: Prof. C. A. Hamberger, Göteberg, Sweden
Dr. Pedro Hernandez Gonzalo, Havana, Cuba
Prof. Eelco Huizinga, Groningen, Netherlands
Prof. Albert von Riccabona, Vienna, Austria

2:00-5:00 p.m.

General Sessions, 5 simultaneous sections
Film Session, Presidential Ballroom

The following activities will be scheduled every day:

8:30-5:00

Registration
Scientific Exhibits
Technical Exhibits
Hospitality Lounge for Foreign Members
Ladies' Committee Hospitality Lounge

Morning and afternoon
Hours to be announced
Sightseeing tours

Each afternoon
Hours to be announced
Medical tours

PAPERS OF THE GENERAL SECTIONS

1.	Die Prognose der operativen Hörbesserung bei chronischer Mittelohrentzündung	Zöllner, Fritz Freiburg, Germany	*German*
2.	The accessory air spaces of the middle ear: morphology, physiology and pathology	Tumarkin, Ivan Alexis Liverpool, England	*English*
3.	Ten years of tympanoplasty in chronic suppurative otitis	DePrest, R. A. Bruges, Belgium	*English*
4.	Tympanoplastic surgery and its long term results	Goto, Shuji Nagoya-Shi, Japan	*English*
5.	Modifizierte zweizeitige tympanoplastik bei chronischer otitis media	Brunar, Max Graz, Austria	*German*
6.	Surgical aspects of tympanoplasty	Verhoeven, Louis Antwerp, Belgium	*English*
7.	Chronic suppuration of the ear and functional surgery	Fabbi, Fabio Bologna, Italy	*English*
8.	Principles of hearing preservation in surgery for chronic ear disease	Juers, A. L. Louisville, Ky.	*English*
9.	Reconstruction of sound conduction of the middle ear	Pick, Emery I. Los Angeles, Calif.	*English*
10.	Zur ätiologie des Mittelohr cholesteatoms	Link, Rud. Berlin-Charlottenburg, Germany	*German*
11.	A new concept of the pathogenesis of aural cholesteatoma based upon studies of the early development of the middle ear	Guggenheim, Paul Topeka, Kansas	*English*
12.	Remarks on the x-ray appearance of the mastoid process in health and suppurative disease	Alexander, A. B. London, England	*English*

13.	Considerations sur la tomographie du temporal	Agazzi, Carlo Cova, P. L., and Senaldi, M. Milan, Italy	*French*
14.	Ueber das sogenannte primäre Cholesteatom des äusseren Gehörganges	Hörbst, Ludwig Innsbruck, Austria	*German*
15.	Perilabyrinthitis	Cawthorne, T. E. London, England	*English*
16.	Sobre microcirugia funcional en las otorreas	Garcia-Ibanez, L. Valencia, Spain	*Spanish*
17.	Tratamiento de las otitis media cronicas supuradas con lavaje permanente con hialuronidasa	Rellan, Raul Maria Buenos Aires, Argentina	*Spanish*
18.	Les fistules labyrinthiques dan les otites moyennes suppurées chroniques	Lapouge, Jean Nice, France	*French*
19.	Radical surgery on the temporal bone and the labyrinth for the improvement of hearing	Niho, Shijo Yokohama, Japan	*English*
20.	Clinical significance of the new conception of otitis media	Nishihata, T., and Nishihata, H. Tokyo, Japan	*English*
21.	The problem of the sterile otitis media	Siirala, Urpo Turku, Finland	*English*
22.	Modern surgery for chronic suppurative otitis media and mastoiditis	Morrison, W. W. New York, N. Y.	*English*
23.	Pathology of otitis media	Friedmann, I. London, England	*English*

24.	The Schwartze mastoidectomy: its value at the present time	McKenzie, William London, England	*English*
25.	La chirurgie fonctionelle des fenêtres labyrinthiques	Portmann, Michel Bordeaux, France	*French*
26.	The first direct prelabyrinthine petrotomy and extended tympano-mastoidectomy with preservation of labyrinthine function	Precechtel, Antonin Prague, Czechoslovakia	*English*
27.	Past and present treatment of otogenous labyrinthitis	Miodonski, Jan Krakow, Poland	*English*
28.	The effect of head movement on positional nystagmus	Aschan, G., Bergstedt, M., Drettner, B., Nylen, C. O., and Stahle, J. Stockholm, Sweden	*English*
29.	The electric goniometer test. A new vestibular function test	Honjo, Shoichi Ube-shi, Japan	*English*
30.	A contribution to clinical electronystagmography	Piroda, E. Cagliari, Italy	*English*
31.	Improved equipment for vestibular testing	Guillemin, Victor, Jr. and Torok, Nicholas Chicago, Illinois	*English*
32.	Nystagmus problems in brain tumor	Morimoto, Masamori Niigata City, Japan	*English*
33.	Farmacodinamia de los drogas inhibidoras del sistema vestibular	Tato, J. M., Fernandez, C., and Rius, M. Buenos Aires, Argentina	*Spanish*

34.	Anomalies in the recorded movement of the eyes during rotatory optokinetic and caloric stimulation in normal subjects	Omerod, F. C. London, England	*English*
35.	Temperature transmission in the caloric test in the os temporal under various anatomical and pathological conditions	Jako, G., Fleischmann, L., and Missurat, T. Budapest, Hungary	*English*
36.	Nouvelle aiguille a paracentése	Bors, C. Bucharest, Rumania	*French*
37.	Fenestración modificado y movilización del estribo (estapedioclasia). Tecnicas, resultados y juicio critico	Antoli-Candela Cebrian, F. Madrid, Spain	*Spanish*
38.	Mobilisation de l'étrier: échecs et espoirs	Clerc, Pierre Paris, France	*French*
39.	La mobilisation de l'étrier dans l'otosclérose	Arslanian, Nubar Genoa, Italy	*French*
40.	Stapedolysis in the treatment of otosclerosis	Goodhill, Victor Los Angeles, Calif.	*English*
41.	Four years' experience with mobilization of the stapes	Werth, Rudolph Tel Hashomer, Israel	*English*
42.	Modified Rosen's operation	Pruvot, Maurice Lille, France	*English*
43.	Mobilisation de l'étrier et ouverture de la fenêtre ovale	Guillon, Henri Paris, France	*French*
44.	Nuestra experienca con la operación de Rosen	Bertran Escanaverino, Raul E. and Basterrechea, Claudio, Jr. Havana, Cuba	*Spanish*

45.	Stapes mobilization and fenestration of oval window for otosclerotic deafness	Rosen, Samuel New York, N. Y.	*English*
46.	The mechanism of hearing loss in early cases of labyrinthine hydrops	Tonndorf, Juergen Iowa City, Iowa	*English*
47.	The humoral cochlear circulation	Borghesan, Ettore Palermo, Italy	*English*
48.	Structural changes in the inner ear under the influence of sound	Engstrom, Hans Göteborg, Sweden	*English*
49.	Sudden perceptive deafness	van Dishoeck, H.A.E., and Bierman, Th. A. Leyden, Netherlands	*English*
50.	The normal hearing reference zero	Glorig, Aram Los Angeles, Calif.	*English*
51.	The present state of the treatment of the hard of hearing in Japan	Kashiwado, Teiichi Tokyo, Japan	*English*
52.	Congenital deafness: analysis of pathological findings	Kelemen, George Boston, Mass.	*English*
53.	On recruitment testing	Palva, Tauno Turku, Finland	*English*
54.	Loudness measurement in a mobile decompression chamber	Pothoven, W. J. Groningen, Netherlands	*English*
55.	The first and second branchial arches: their developmental history and adult contribution to the auditory apparatus in man	Anson, B. J. Chicago, Illinois and Bast, T. H. Madison, Wisconsin	*English*

56.	Prevention of adverse effects of streptomycin on the ear	Ozaki, Tomoharu Nara-ken, Japan	*English*
57.	Research in normal hearing threshold	Albrite, J. P. and Shutts, R. Edwin Washington, D.C.	*English*
58.	Sodium bicarbonate injection in the prevention of motion sickness	Muta, Minoru Osaka, Japan	*English*
59.	New investigations on seasickness	Nieuwenhuijsen, J. H. Rotterdam, Netherlands	*English*
60.	Nistagmus pervertido. Su significacion clinica	Riesco-MacClure, J. S., and Martinez, Alfonso Santiago, Chile	*Spanish*
61.	Psychogenic vertigo: the importance of its recognition	Moore, Burness E. and Atkinson, Miles New York, N. Y.	*English*
62.	Electrophysiological and cytochemical studies on ototoxicity of dehydrostreptomycin	Nakamura, Fumio Kioto, Japan	*English*
63.	Ueber Spätfolgen der petrogenen Hirnabsesse	Fleischmann, L. Budapest, Hungary	*German*
64.	Chemodectoma or tumor of the glomus jugulare of tympanic body	Capps, F.C.W. London, England	*English*
65.	The function testing of inner ear windows	Horiguti, Sinsaki Tokyo, Japan	*English*
66.	Intravascular agglutination of the blood. A factor in several diseases and disorders of the ear	Fowler, Edmund P. New York, N. Y.	*English*

67.	An oto-audiological investigation of premature children	Campanelli, P. A. Henner, R., and Pollock, F. J. Chicago, Illinois	*English*
68.	An objective test method for the evaluation of middle ear function	Holcomb, A. L. Los Angeles, California	*English*
69.	Hearing conservation program in U. S. Air Force	Kraus, Ralph N. Randolph Field, Texas	*English*
70.	Studies on the clinical masking level	Harbert, Fred Philadelphia, Pa.	*English*
71.	Progression of cochlear nerve degeneration in otosclerosis as estimated by audiogram	Roy, S.R.D.N. Tamluk, India	*English*
72.	Anatomical and clinical reclassification of the tympanic spaces and the eustachian tube	Schwarzbart, Adolph A. Tel-Aviv, Israel	*English*
73.	Stapes mobilization: lasting results of 1 and 2 years	Muerman, Y. and Meurman, O. Helsinki, Finland	*English*
74.	Improvement of hearing in otosclerosis by means of stapes mobilization	Ronis, B. J., and Myers, David Philadelphia, Pa.	*English*
75.	Visualization of the fenestra ovalis in the operation for mobilization of the stapes	Bellucci, Richard J. New York, N. Y.	*English*
76.	Mobilization of the stapes in otosclerotic deafness	Alexander, Lucian W. New Orleans, La.	*English*
77.	Progress and observations of transtympanic mobilization of the stapes	Scheer, Alan A. New York, N. Y.	*English*

78.	Considerations on mobilization of the stapes for otosclerosis	Myerson, M. C. Beverly Hills, California	*English*
79.	Ausmeisselung der Steigbügel Grundplatte	Heerman, Hans Essen, Germany	*German*
80.	Heparin in the treatment of Meniere's disease	Schenck, Harry P. Philadelphia, Pa.	*English*
81.	Ablation therapy for Meniere's disease	Schuknecht, Harold F. Detroit, Michigan	*English*
82.	Simultaneous registration of vestibular nystagmus and counter-rolling of the eyes	Kuilman, J. The Hague, Netherlands	*English*
83.	Occupational hearing loss	Fox, Meyer S. Milwaukee, Wisconsin	*English*
84.	Evaluation of the signs of end-organ deafness	Simonton, K. M. Rochester, Minn.	*English*
85.	Medical and surgical treatment of Bell's palsy	Fowler, Edmund P., Jr. New York, N. Y.	*English*
86.	Normal and abnormal activity of the human otoliths	Sullivan, J. A. and Johnson, Walter Toronto, Canada	*English*
87.	Le traitement chirurgical des vertiges par l'ouverture du sac endolymphatique	Portmann, Georges Bordeaux, France	*French*
88.	Les otites adhesives et leur traitement chirurgical	Maspetiol, Roger Paris, France	*French*

89.	L'ostéite condensante de l'oreille moyenne	Andrieu-Guitrancourt, S. A., and Laumonier, R. Rouen, France	*French*
90.	Le tympanelectronique endaural	Aubert, Maurice, and Miquelis, Eugene Nice, France	*French*
91.	Ueber den Einfluss des Labyrinthreizes auf die Funktion des autonomen Nervensystems	Fujisaki, Shigemi Osaka, Japan	*German*
92.	The effect of succinylocholine on the middle ear muscles and on transmission of sound through the middle ear	Gisselsson, L. Lund, Sweden	*English*
93.	Retroauriculaire fistule symptom	Grec, Stamatios Petalas Budapest, Hungary	*French*
94.	Valeur de la conservation du tissu adipeux pieleve sur le vivant et sur le cadavre dans la chirurgie de l'os temporal	Penha, Guilherme Coimbra, Portugal	*French*
95.	Surdites centrales avec recruitment dans le syndrome de Wallenberg	Greiner, G. F., Theibaut, F., and Mengus, M. Strasbourg, France	*French*
96.	Audiocirugia. Recuperación de las sorderas por otorrea or secuelas	Antoni-Candela Piquer, F. Valencia, Spain	*Spanish*
97.	Chronic middle ear infection among Filipinos	Garcia, Tierry F. and Fernando, Asuncion Manila, Philippines	*English*

98.	Topic diagnosis in facial nerve paresis	Kristensen, Harold K. Copenhagen, Denmark	*English*
99.	Reflexions au sugjet de abcès encéphaliques oto-rhinogènes	Larroude, Carlos Lisbon, Portugal	*French*
100.	The dry fenestration technique	Lempert, Julius New York, N. Y.	*English*
101.	The fenestration operation: lasting results through refinements in technique	Farrior, J. Brown Tampa, Florida	*English*
102.	Non-chromaffin paraganglioma of the head	Lederer, F. L., Skolnik, E. M., Fornatto, E. J., and Soboroff, B. J. Chicago, Illinois	*English*
103.	Sur le colèsthéatome du rocher du temporal et de la base du crane	Racoveanu, Virgil & Anghelide, Radu Bucharest, Rumania	*French*
104.	Myringoplasty: Plastic repair of ear drum perforations	Pietrantoni, Luigi and Bocca, Ettore Milan, Italy	*English*
105.	External umbo blebs. Non-inflammatory lipoid vesicles of the tympanic membrane	Armstrong, B. W. Charlotte, N. C.	*English*
106.	Chloromycetin en las otitis cronicas supuradas	Tombolini, Jorge J. San Lorenzo, Argentina	*Spanish*
107.	The labyrinth test in the syndrome of Barre	Demetriades, Theodore D. Athens, Greece	*English*

108.	Interesting cases in pediatric otolaryngology	Sharp, H. S. London, England	*English*
109.	Surgical treatment of chronic sinusitis with special reference to the external frontal approach	Kurosu, Minokichi Tokyo, Japan	*English*
110.	Transnasal destruction of the pituitary gland for secondary carcinomatosis in hormone dependent neoplasms	Bateman, G. H. London, England	*English*
111.	Recherches histo-pathologique sur l'agmidale dans les maladies collagenes	Ferreri, Giorgi Rome, Italy	*English*
112.	The pterygopalatine ganglion and its anesthesia applied to otalgic, glossopharyngeal pains and certain forms of vasomotor disturbances of the nose	Laskiewicz, A. London, England	*English*
113.	Vascular surgery in otolaryngology	Loré, John M. New York, N. Y.	*English*
114.	Experiences in the treatment of the allergic nasal polyp by the injection of hydrocortisone T.B.A. and Prednisolone T.B.A.	Myers, David and Ronis, B. J. Philadelphia, Pa.	*English*
115.	El colageno en la fisiopathologia del escleroma	Sanchez Cortes, Jose, Maranjo, Ramon, and Montes de Oca, Edmundo Guadalajara, Mexico	*Spanish*
116.	Malignant granuloma of the nose	Ellis, Maxwell P. London, England	*English*
117.	Clinical study of local treatment of allergic rhinitis	Evans, W. H. Youngstown, Ohio	*English*

118.	Versuche postoperative mesenchymale Reaktionen zu beeinflüssen	Malecki, J. Lodz, Poland	*German*
119.	Vasomotor rhinitis	Goldman, Joseph L. New York, N. Y.	*English*
120.	Nasal allergy	Aiyar, R. D. Denbigh, Wales	*English*
121.	Stress and hypadrenocorticism: the implications in otolaryngology	Goldman, Herbert B. Rockville Center, New York, and Tintera, John W. Yonkers, N. Y.	*English*
122.	Optimum dosage therapy in respiratory allergy and in infection	Hansel, French K.	*English*
123.	Allergie u. respirationstrakt	Hussarek, Max Vienna, Austria	*German*
124.	The treatment of rhinoscleroma locally by aureomycin	El-Mofty, Aly Cairo, Egypt	*English*
125.	Rhinitis hipertroficas en Venezuela	Gonzalez Vera, P. Caracas, Venezuela	*Spanish*
126.	The effect of antrotomies with negative findings on the improvement of nutritional disturbances in infant age	Baraat Budapest, Hungary	*English*
127.	The congenital malformation of nasal structure	Horowitz, Michael S. London, England	*English*
128.	The surgical treatment of nasal polypi	Korkis, F. Boyes London, England	*English*

129.	Radical frontal sinus surgery	Goodale, Robert L. Boston, Mass.	*English*
130.	Pathology of the sphenoid	Hirsch, Oscar Boston, Mass.	*English*
131.	Branchial anomalies	Albers, G. Donald Grand Rapids, Mich.	*English*
132.	Choanal polyps	Van Alyea, O. E. Chicago, Illinois	*English*
133.	Chronic osteitis of the maxilla in relation to maxillary sinusitis	Fleming, W. E. Melbourne, Australia	*English*
134.	Transethmoid-sphenoidal hypophysectomy in metastasis of breast cancer	Escher, Franz Bern, Switzerland	*English*
135.	Rhinosporidiosis in nasopharynx	Burad, Ermin Ankara, Turkey	*English*
136.	Observations on the exchange of fluid in the nose and respiratory tract	Negus, Victor London, England	*English*
137.	Die motorischen Nerven des Kehlkopfes und deren retrograder Funktionausfall	Hofer, Gustav Graz, Austria	*German*
138.	Rhinoplasty in Japan with special reference to second grade of physiologic saddle nose	Ishii, Toshi Yokohama, Japan	*English*
139.	New things in plastic surgery of the nose	Seltzer, Albert P. Philadelphia, Pa.	*English*
140.	Correction of the deviated nose	Goldman, Irving B. New York, N. Y.	*English*

141.	Anatomy and function of the nasal vestibule	Williams, Russell I. Cheyenne, Wyo.	*English*
142.	Skin replacement for severe radiation of the face: a one-stage procedure by free graft or pedicle flap rotation	Conley, John J. New York, N. Y.	*English*
143.	Food allergy in the ear, nose and throat practice of allergy	Missal, S. C. Cleveland, Ohio	*English*
144.	A biochemical and cytological study of tonsils	Saito, Hideo, and Nakamura, Shiro Tokyo, Japan	*English*
145.	Die operative Behandlung der beideseitigen totalen recuren parese	König, E. Bad Homburg, Germany	*German*
146.	Sur l'allergie nasosinusienne	Lazeaunu, Mihail and Racoveanu, Virgil Bucharest, Rumania	*French*
147.	Surgical access to the nasopharynx	Wilson, C. P. London, England	*English*
148.	Malignant tumors of the paranasal sinuses	Struben, W. H. Amsterdam, Netherlands	*English*
149.	Spätresultaten in der behandlung der operativen verlätzung des gesichtsnerven im säuglingsalter	Kallay, Franz Budapest, Hungary	*German*
150.	Results in cases of rhinolalia aperta	Missura, T. Budapest, Hungary	*English*
151.	New developments in plastic surgery of the nose and ear	Converse, John M. New York, N. Y.	*English*

152.	Submucous fibrosis of the palate	DeSa, Joseph V. Bombay, India	*English*
153.	Elongated styloid process: symptoms and treatment	Eagle, Watt W. Durham, N. C.	*English*
154.	Ectopic salivary adenomas	Harrison, Kenneth Manchester, England	*English*
155.	Mixed tumors of the palate	Montreuil, Fernand Montreal,Canada	*English*
156.	End results of the management of parotid tumor	Perzik, S. L. Beverly Hills, California	*English*
157.	Nasopharyngeal fibroma	Satyanarayana, C. Madras, India	*English*
158.	Nasopharyngeal cancer: present status	Miller, Daniel Boston, Mass.	*English*
159.	Anesthesia in peroral endoscopy: a new method	Adler, H. J., Reed, W. A., and Frerichs, D. A. Phoenix, Arizona	*English*
160.	Neurogenic tumors of upper respiratory tract	Ash, James E. Bethesda, Md.	*English*
161.	Submucous fibrosis of oropharynx (a collagen disorder)	Rao, R. Venkata New Delhi, India	*English*
162.	Adenoidectomy under visualization	Holt, John A. B. Charleston, W. Va.	*English*
163.	Sinography especially with reference to block dissection of the neck	Frenckner, Paul Stockholm, Sweden	*English*

164.	Tracheotomy	Steinberg, Edgar I. Los Angeles, California	*English*
165.	The innervation of the larynx	Rethi, A. Budapest, Hungary	*English*
166.	Transoral intralaryngeal approach for arytenoidectomy in bilateral abductor vocal cord paralysis	Thornell, William C. Cincinnati, Ohio	*English*
167.	Neurology and function of the pharynx and its powers of compensation in paralysis	Keogh, Charles London, England	*English*
168.	Magnetic removal of foreign bodies from the stomach and duodenum	Equen, Murdock Atlanta, Ga.	*English*
169.	The laryngologist and resuscitation of the newborn	Goff, Willard F. Seattle, Wash.	*English*
170.	Discrimination entre les diverses thérapeutiques des tumeurs malignes de l'amygdale palatine	Cambrelin, G. Brussels, Belgium	*French*
171.	Composite grafts for the repair of alar defects	Becker, Oscar J. Chicago, Illinois	*English*
172.	Zur Prophylaxe von Nachblutung und Zwischenfällen bei der Tonsillektomie	Hohlbrugger, Herman Innsbruck, Austria	*German*
173.	Le rôle de l'air dans la vibration des cordes vocales	Vallancien, Bernard Paris, France	*French*
174.	The significance of endobronchial lesions in the management of pulmonary tuberculosis	O'Keefe, John J. Philadelphia, Pa.	*English*

175.	Les oesophagites par reflux	Gaillard, J., and Mounier-Kuhn, P. Lyon, France	*French*
176.	Observation upon the experimental use of radioactive isotopes within the larynx	Pressman, Joel J., Dowdy, Andrew, Libby, Raymond, and Fields, Max Los Angeles, California	*English*
177.	Vocal rehabilitation of paralytic dysphonia	Arnold, Godfrey E. New York, N. Y.	*English*
178.	Vocal cord polyps: psychiatric observation on the personality structure of patients with habitual dysphonia	Heaver, Lynwood New York, N. Y.	*English*
179.	Stenosing peptic esophagitis	Friedberg, Stanton A. Chicago, Illinois	*English*
180.	Tratamiento de la ventilación pulmonar insuficiente en enfermos sin obstrucción laringea	Barani, Julio C. Montevideo, Uruguay	*Spanish*
181.	Quiste intralaringea	Revuelta Alonso, Rene, and Mateo Oma, Luis Havana, Cuba	*Spanish*
182.	Papiloma de laringe	Ameriso, Jose Rosario, Argentina	*Spanish*
183.	Considérations sur a papilomatose du larynx	da Costa Quinta, Antonio Lisbon, Portugal	*French*

184.	Papilloma of the larynx: a case of protracted duration, 1878-1955	Jesberg, Norman Los Angeles, California	*English*
185.	Surgical treatment of multiple recurrent obstructive papillomata of the larynx	Woodman, De Graaf New York, N. Y.	*English*
186.	Ueber das pH in der O.R.L. insbesondere bei Papillome des larynx	Yannoulis, G. E. Thessaloniki, Greece	*German*
187.	Laringofisura en el tratamiento de la Papilomatosis laringea	Celis Perez, A. Valencia, Venezuela	*Spanish*
188.	La papillome et son problème thérapeutique	de Sanson, Raul D. Rio de Janeiro, Brazil	*French*
189.	Reconstrucción quirurigica de laringes estenosadas	Aleman Caballero, Rene Seville, Spain	*Spanish*
190.	Carcinoma of the larynx	Jackson, Chevalier L. Philadelphia, Pa.	*English*
191.	The classification of carcinoma of the larynx based on topography	King, G. David Boston, Mass.	*English*
192.	Some selected problems in cancer of the larynx	Orton, Henry B. Newark, N. J.	*English*
193.	Effect of preoperative radiation on subsequent surgery in cancer of the larynx	Trible, William M. Washington, D. C.	*English*
194.	Traitement du cancer de la base de la langue	Labayle, J., and Huet, R. D. Paris, France	*French*

195.	Heredity in cancer of the larynx	Fior, Renato Milan, Italy	*English*
196.	Datos sobre casuistica y terapeutica del cancer laryngea	Ager Muguerza, Enrique Madrid, Spain	*Spanish*
197.	Consideraciones sobre etiologica, caracteristicas, localización y distribución del cancer de la laringe en Espana. Derivada de nuestra estadistica	Paredero del Bosque, J. Madrid, Spain	*Spanish*
198.	Preventive neck dissection in cancer of the larynx	Putney, F. Johnson Philadelphia, Pa.	*English*
199.	Laryngo-esophagectomy: primary closure with laryngo-tracheal autograft	Som, Max J. New York, N. Y.	*English*
200.	Etude critique des nouveaux procédés d'explanation bronchoesophagienne	Soulas, Andre, Paris, France, and Mounier-Kuhn, P. Lyon, France	*French*
201.	Observations on the voice and their application	Lodge, William O. Halifax, England	*English*
202.	Neuere Methoden der allgemeinen Betaübung für die bronchoscopie	Riecker, O. E. Wuppertal-Barmen, Germany	*German*
203.	Tissue culture studies in juvenile papilloma of the larynx	Brewer, David W., and Kalter, Seymour Syracuse, N. Y.	*English*

204.	Traitement des papillomes larynges des enfants par les antibiotiques	Zakrezewski, Alexandre, and Sobocynski, Andre Posnan, Poland	*French*
205.	Consideration etiologique à-propos d'un cas de tracheomalacia	Mounier-Kuhn, P., Heimindinger, E., and Klotz, G. Strasbourg, France	*French*
206.	Considerations sur le papillomatose du larynx	Negrea, A., and Bors, D. Bucharest, Rumania	*French*
207.	Some considerations about papilloma of the larynx	Amarante, Rubem C. L. Rio de Janeiro, Brazil	*English*
208.	Treatment of serious esophagus stenosis	Koleszar, G. Budapest, Hungary	*English*
209.	Treatment of laryngeal papilloma in children with resin of podophyllin	DeVido, G., and Megighan, D. Treviso, Italy	*English*
210.	Postlaryngectomy pharynx fistula and the ribbon muscles	Singer, Rudolf New York, N. Y.	*English*
211.	Contact ulcer: new observations and therapy	von Leden, Hans and Moore, Paul Chicago, Illinois	*English*
212.	(Incomplete)	Groen, J. J. Utrecht, Netherlands	*English*

213. (Incomplete)	Aubin, Andre Paris, France	*French*
214. (Incomplete)	Melampi, Mario Genoa, Italy	*French*
215. Case of pharyngolith	Ulug Resat, Ali Ankara, Turkey	*English*

ALTERNATIVE PAPERS

Repair of tympanic membrane perforations	Elia, Joseph C. West Haven, Conn.	*English*
Surgical management of complete and incomplete atresia of the posterior nares	Beinfeld, Henry H. Brooklyn, N. Y.	*English*
Sinusitis and non-specific endogenous ocular inflammations	Lubart, Joseph New York, N. Y.	*English*
Stress rhinology	Poos, Edgar E. Detroit, Mich.	*English*
Psychological preparation of children for surgery	Coleman, Lester L. New York, N. Y.	*English*
The culmination phenomenon and frequency pattern of thermic nystagmus	Torok, Nicholas Chicago, Ill.	*English*
Nose and nasality	Froeschels, Emil New York, N. Y.	*English*
A new method of decompression in malignant exophthalmos	Biber, J. J. Delaware, Ohio	*English*
Case report: Sudden fatal termination in case of otitis media	Loomis, George Winona, Minn.	*English*

An analysis of blood and vascular factors in the prophylaxis of tonsillo-adenoidal surgery	Coyle, James E. Detroit, Mich.	*English*
Conservative management of chronic otitis media	Sanderson, Bruce A. San Diego, Calif.	*English*
Bronchogenic carcinoma, with report of a case	Strong, M. Stuart, and Sommers, Sheldon C. Boston, Mass.	*English*
The role of the vocalis muscle in human phonation	Fink, R. Bernard New York, N. Y.	*English*
The adenoid-tonsil problem: a review of 5000 cases	Rigg, James P. Grand Junction, Colorado	*English*
Bilateral thyrotomy: revaluation after 5 years	Kemler, Joseph I. Baltimore, Md.	*English*
Hypopharyngeal diverticulum	Shepard, Willis B. Eugene, Oregon	*English*
Bleeding problems and the otolaryngologist	Simmons, Marvin W. Fresno, Calif.	*English*
Postoperative hemorrhage related to atmospheric changes	Utrata, Joseph Chillicothe, Ohio	*English*
Epistaxis. The need for new and improved methods of treatment	Woodruff, George H. Joliet, Illinois	*English*
Transantral decompression for malignant exophthalmos	Walker, James S. and Porter, G. LeRoy Urbana, Illinois	*English*
A short study of papilloma of the larynx	Shanks, Joseph Chicago, Illinois	*English*

Physiology of breathing and colds	Josephson, Emanuel M. New York, N. Y.	*English*
Ultrasonics, resonance and deafness	Angeluscheff, Zhivo D. New York, N. Y.	*English*
Quelques aspects particuliers en ce qui concerne les modifications auditives consecutives au traitement chirurgical des suppurations oto-mastoidiennes	Neuman, H., Falutz, S., Muntenescu, M., and Craciun, E. Bucharest, Rumania	*French*
The problem of the papillomatous larynx as a precancerous condition	Marin, Aurel, and Mestes, Eugen Bucharest, Rumania	*English*
Recherches experimentales dans l'allergie nasale	Laurian, N., Lengyel, A., Mestes, E., Ursu, E., Cociumian, L., Bujum, O., and Obreja, S. Bucharest, Rumania	*French*
Contributions a la conduite therapeutique de la papillomatose laryngee	Nerescu, V. Bucharest, Rumania	*French*
The allergic tissue with special reference to eosinophils and ground substance alteration	Hlavacek, Vladimir Prague, Czechoslovakia	*English*

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Applications for the presentation of films have been sufficient to provide 18 hours of motion pictures which will run simultaneously with the presentation of scientific papers.

Notices

ACADEMY HOME STUDY COURSES

The 1956-1957 Home Study Courses in the basic sciences related to ophthalmology and otolaryngology, which are offered as a part of the educational program of the American Academy of Ophthalmology and Otolaryngology, begin on September 1 and continue for a period of ten months. Detailed information and application forms can be secured from Dr. William L. Benedict, the executive secretary-treasurer of the Academy, 100 First Avenue Building, Rochester, Minnesota. Registrations should be completed before August 15.

AMERICAN LARYNGOLOGICAL ASSOCIATION

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AN INTERNATIONAL CONFERENCE ON AUDIOLOGY

1. There will be an International Conference on Audiology in St. Louis beginning the afternoon of May 13 and continuing through May 16, 1957. The Conference will be included as part of Tours 2

and 3 (to the Middle West and Far West) that are being planned in connection with the Sixth International Congress of Otolaryngology to be held in Washington in May 1957.

2. The following themes will be discussed: a) The Assessment of Auditory Function; b) The Physiology of Audition; c) The Relation of Hearing Loss to Noise Exposure.

The program has not been finally crystallized but it is likely that the majority of papers will be invited ones. One afternoon has been set aside for a small number of contributed papers relevant to the themes of the Conference. Persons desiring to contribute papers should submit an abstract to the Program Chairman no later than March 1, 1957. The aim of the Conference is to have scientists and clinical workers share views and findings on the above subjects. Visits to local audiological and otological facilities will be included.

3. The Chase Hotel is the official hotel of the Conference, but housing elsewhere at varying prices will be available. There will be a nominal registration fee, not yet determined.

4. The Conference is being partly supported by a grant from the National Science Foundation to the Central Institute for the Deaf.

5. The Program Chairman is Dr. Ira J. Hirsh, Research Associate, Central Institute for the Deaf, 818 South Kingshighway, St. Louis 10, Missouri.

6. The National Organizing Committee is:

Raymond Carhart, Ph.D., Professor of Audiology, Northwestern University

Hallowell Davis, M.D., Director of Research, Central Institute for the Deaf; Research Professor of Otolaryngology and Professor of Physiology, Washington University School of Medicine

Harvey Fletcher, Ph.D., Director of Research, Brigham Young University; formerly Physical Research Director, Bell Telephone Laboratories

William G. Hardy, Ph.D., Director, Speech and Hearing Center; Associate Professor of Otolaryngology and Environmental Medicine, Johns Hopkins Hospital, Baltimore, Maryland.

John Lindsay, M.D., Professor of Otolaryngology, University of Chicago

Philip E. Meltzer, M.D., Professor of Otolaryngology, Tufts University Medical School

S. S. Stevens, Ph.D., Professor of Psychology, Harvard University

S. R. Silverman, Ph.D., Director of Central Institute for the Deaf; Professor of Audiology, Washington University; Chairman

7. Additional plans will be communicated as they are formulated. For information write to: S. R. Silverman, Chairman, International Conference on Audiology, Central Institute for the Deaf, 818 South Kingshighway, St. Louis 10, Missouri.

INTERNATIONAL VOICE CONFERENCE

(Laryngeal Research, Function and Therapy), Chicago, Illinois, U.S.A., May 20-22, 1957. For information address: Dr. Hans von Leden, 30 North Michigan, Chicago 2, Ill., U.S.A.

TULANE UNIVERSITY OF LOUISIANA SCHOOL OF MEDICINE

The three year residency in otolaryngology offered at Charity Hospital of Louisiana at New Orleans on the Tulane University of Louisiana School of Medicine service is designed to qualify the holder for the examinations of the American Board of Otolaryngology and the practice of all phases of otolaryngology and endscopy.

Candidates must be graduates of a class A medical school and must have completed a minimum of one year of general internship. An additional year of residency in internal medicine or general surgery is desirable but not essential.

All work is under the direct supervision of members of the Tulane Department of Otolaryngology, who are also members of the Charity Hospital Otolaryngological Staff; they are available at all times for instruction and guidance. Basic sciences are offered throughout each year of the residency during the academic year. The resident also participates in the program of the Speech and Hearing Center at the Tulane University School of Medicine.

The hospital year extends from July 1 of one year to June 30 of the following year.

Applications should be addressed to the Chairman of the Department of Otolaryngology, Tulane University of Louisiana School of Medicine, 1430 Tulane Ave., New Orleans 12, Louisiana.

INDIANA UNIVERSITY MEDICAL CENTER

The Department of Otolaryngology, Indiana University School of Medicine, offers its annual Anatomical and Clinical Course in Otolaryngology March 25th to April 6th, 1957.

Applicants should address the Post-Graduate Office, Indiana University Medical Center, Indianapolis 7, Indiana.

TEMPLE UNIVERSITY
SCHOOL OF MEDICINE AND HOSPITAL

Postgraduate Course in Bronchoesophagology, February 11-22, 1957; May 20-31, 1957; September 9-20, 1957.

Postgraduate Course in Laryngology and Laryngeal Surgery, March 11-22, 1957; November 4-15, 1957.

These courses are all to be given in the Department of Laryngology and Broncho-Esophagology, Temple University Hospital and School of Medicine, under the direction of Doctors Chevalier L. Jackson and Charles M. Norris. The tuition fee for each course is $250.00. Further information and application blanks can be obtained from Dr. Chevalier L. Jackson, 3401 N. Broad Street, Philadelphia 40, Pa.

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Secretary-General: Paul H. Holinger, M.D., 700 North Michigan Ave., Chicago 11, Ill., U. S. A.
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International Bronchoesophagological Society

President: Dr. Theodor Hünermann, Düsseldorf
Secretary: Dr. Chevalier L. Jackson, 3401 N. Broad St., Philadelphia 40, Pa.
Meeting: Philadelphia, May 12 and 13, 1957.

Pan-American Association of Oto-Rhino-Laryngology and Broncho-Esophagology

President: Dr. Jose Gros, Havana
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Meeting: Sixth Panamerican Congress, Brazil, 1958 or 1959

American Academy of Ophthalmology and Otolaryngology

President: Dr. Algernon B. Reese, New York.
Executive Secretary: Dr. William L. Benedict, Mayo Clinic, Rochester, Minn.

American Board of Otolaryngology

President: Dr. Gordon D. Hoople, Syracuse, N.Y.
Secretary: Dr. Dean M. Lierle, University Hospital, Iowa City, Iowa.

American Broncho-Esophagological Association

President: Dr. Clarence W. Engler, Cleveland, O.
Secretary: Dr. F. Johnson Putney, 1719 Rittenhouse Sq., Philadelphia 3, Pa.
Meeting: None, in 1957; San Francisco, Calif., May 21, 22, 23, 1958.

American Laryngological Association

President: Dr. LeRoy A. Schall, Boston.
Secretary: Dr. Harry P. Schenck, 326 South 19th St., Philadelphia, Pa.
Meeting: Hotel Statler, Washington, D.C., May 3, 1957.

American Laryngological, Rhinological and Otological Society, Inc.

President: Dr. Dean M. Lierle, Iowa City.
Secretary: Dr. C. Stewart Nash, 708 Medical Arts Bldg., Rochester, N. Y.
Meeting: Section meetings only in 1957.

American Medical Association, Section on Laryngology, Otology and Rhinology

Chairman: Dr. John R. Lindsay, Chicago, Ill.
Secretary: Dr. Hugh A. Kuhn, Hammond, Ind.

American Otological Society

President: John R. Lindsay, M.D., Chicago.
Secretary-Treasurer: Lawrence R. Boies, M.D., University of Minnesota Hospitals, Minneapolis 14, Minnesota.
Meeting: Hotel Statler, Washington, D.C., May 4, 1957.

The American Society of Ophthalmologic and Otolaryngologic Allergy

President: Dean McAllister Lierle, M.D., University Hospital, Iowa City, Iowa.
Secretary: Michael H. Barone, M.D., 468 Delaware Avenue, Buffalo 2, New York.

Pacific Coast Oto-Ophthalmological Society

President: H. Leroy Goss, M.D., 620 Cobb Building, Seattle 1, Wash.
Secretary-Treasurer: Homer E. Smith, M.D., 508 East South Temple, Salt Lake City, Utah.
Meeting: Coronado, California, April 7-11, 1957.

Canadian Otolaryngological Society

President: Dr. G.M.T. Hazen, 208 Canada Bldg., Saskatoon, Sask.
Secretary: Dr. G. A. Henry, Medical Arts Bldg., Suite 328, Toronto, Ont.
Meeting: Banff Springs Hotel, June 17, 18 & 19, 1957.

The Society of Military Otolaryngologists

President: Col. Wendell A. Weller, 3810 USAF Hospital, Maxwell AFB, Alabama
Secretary-Treasurer: Major Stanley H. Bear, M.C., 3810th USAF Hospital, Maxwell AFB, Alabama.

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